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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

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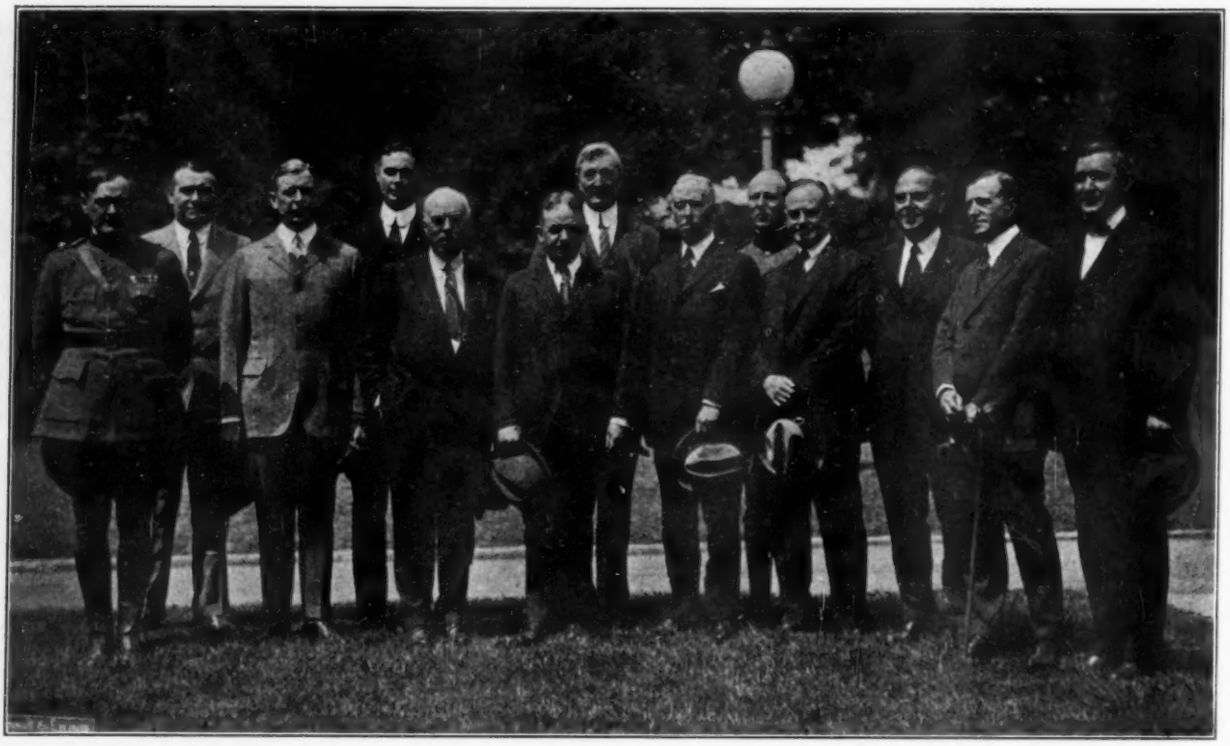
Ordnance District Chiefs Visit the White House



From left to right: Maj. Gen. C. C. WILLIAMS, Chief of Ordnance; Col. BASCOM LITTLE, Chief of the Cleveland Ordnance District; Col. DWIGHT F. DAVIS, Assistant Secretary of War; Col. JOHN ROSS DELAFIELD, Chief of the New York Ordnance District; Mr. R. M. DRAVO, Chief of the Pittsburgh Ordnance District; Colonel CHARLES H. TENNEY, Chief of the Boston Ordnance District; Mr. J. C. JONES, Chief of the Philadelphia Ordnance District; Mr. HOWARD BRUCE, Chief of the Baltimore Ordnance District; Brig. Gen. WILLIAM S. PEIRCE, Assistant to the Chief of Ordnance; Col. BRUCE CORNWALL, Chief of the San Francisco Ordnance District; Col. C. L. HARRISON, Chief of the Cincinnati Ordnance District; Mr. E. A. RUSSELL, Chief of the Chicago Ordnance District, and Col. B. A. FRANKLIN, Chief of the Bridgeport Ordnance District.

ON Monday, May 7th, the Chiefs of the Ordnance Districts were received at the White House by the President. The above photograph was taken as the party left the Executive Offices.

Prior to the visit to the White House, a most interesting meeting of the District Chiefs with the officers of the Ordnance Department, was held in the Office of the Chief of Ordnance. Plans for industrial preparedness were discussed and excellent results were reported.

Great progress has been made in the work of allocating specific war orders to industrial organizations. It is expected that all essential items of ordnance material will be completely allocated before December 1. The response of industry to the scheme of industrial mobilization has been most encouraging.

It may be said that the results achieved thus far amply bear out the correctness of the basic theory that industrial mobilization must hinge on decentralized procurement in the hands of men of large affairs who have the confidence and support of the industrial leaders in their respective districts.

Editorials

"The Right to Keep and Bear Arms"

APROPOS of the general topic to which this issue of ARMY ORDNANCE is devoted, there has been much discussion recently in the press and elsewhere of a proposed Federal bill which, if enacted, would put a prohibitive tax on the manufacture and importation of pistols and revolvers. Chief Magistrate McAdoo, of New York, requested recently all Chiefs of Police throughout the country to support the bill.

Thus another clumsy attempt is being made to remedy the *abuse* of a right by prohibiting its *use*. Assuming such a law upon the statute books, its mantle of protection would fall chiefly upon the criminally minded. The respectable law-abiding citizen would obey it and go unarmed; the burglar and the bandit would ply their trades with added security and, of course, with no more respect for the anti-pistol law than for the others they are flaunting.

A really effective remedy against the use of the pistol for illegitimate purposes would be to punish *this* use. Certainly a bandit who carries a pistol has it in his possession for other purposes than self defense. Let the possession of a pistol by a person who commits or attempts to commit a felony be presumptive evidence of an intent to use the pistol in support of his crime. A mandatory sentence of, say, five years for this intent in addition to the normal penalty for the crime, would go far toward making "pistol toting" by criminals unwise and would leave the respectable citizen free to defend himself in accordance with his constitutional guarantee. The oft worked "police power" could doubtless be made to cover this case.

Fortunately, the proposed bill has an obstacle to overcome that may be insurmountable. The Constitution of the United States provides that "the right of the people to keep and bear arms shall not be infringed." It is hoped that there are evidences of at least a slight return to the old-fashioned respect in which our ancestors held the Constitution. The pertinent examples of the chaotically governed countries of Russia and China cannot help to give pause to those whose respect for principles slowly forged out upon the anvil of time is less than their confidence in a boundless egotism.

There is another angle to the situation, also, which is of particular concern to the development of Ordnance and to industrial preparedness.

The blow that the enactment of the proposed law would deal to the art of Ordnance is obvious. The art must be kept alive if our status as a nation is to be maintained. It is already finding difficulty in surviving both from the military and from the civilian points of view. The total appropriation this year for the entire Ordnance Department is slightly more than five and one-half million dollars; in 1910—certainly a normal pre-war year—the Department received over ten million dollars to carry on its work. Whether the importance of the question is not understood, or whether there is a misconception of facts we do not know; but one thing is certain: the art of arms must not be allowed to die nor be legislated out of existence.

The principle involved, the right at stake, and the freedom of the individual and the nation demand a proper realization of the principles concerned and of the necessary steps to safeguard them.

National Manufacturers Pledge Aid to Defense Plans

THE National Association of Manufacturers at its annual convention in New York recently went on record as favoring adequate industrial preparedness. The resolutions passed by the Association were as follows:

> "We recognize and appreciate the necessary services of land and sea forces in the protection and promoting of our national interests. The Army and Navy must have that adequate support which will maintain the services at the highest necessary efficiency and allow for that reasonable degree of experimentation in new methods of protective development.
>
> "The association pledges its aid in the execution of plans now being developed under the supervision of the Assistant Secretary of War in conformity with the National Defense Act to enable industry promptly and harmoniously to cooperate with the Government in taking advantage of the lessons of war in preparing adequate plans for the mobilization of industry and civilian training in the event of national need.
>
> "A proper respect for our domestic and foreign obligations requires the maintenance of the Navy and other protective forces at all times in high effectiveness to the full limits of international treaties and agreements.
>
> "We commend the condemnation by the Committee on Naval Affairs of the House of Representatives of the insidious proposal of the Hull bill to convert our arsenals and navy yards into Government manufacturing establishments, competing with private industry under a misleading method of estimating actual production cost."

This is a most encouraging act on the part of one of our largest and most influential organizations. We need more of such open and candid action from those who are in a position to mould public opinion.

The National Association of Manufacturers is composed of companies and individuals who know by experience the strains and stresses of war; their expression is based on actual contact with the problems envolved.

Therefore, their action is deserving of highest commendation. The Army Ordnance Association welcomes to the ranks of industrial preparedness an organization that can add such prestige to the cause.

Intolerance

SOMETIME since there was considerable stir caused by a group of well-intentioned individuals who protested against certain speeches on preparedness by Brigadier General Amos A. Fries, Chief of Chemical Warfare Service, U. S. A. Now that the smoke has cleared away one can see the affair in something of its proper perspective.

General Fries has a faculty often lacking in public speakers—he has something to say and he says it. In advocating adequate peacetime preparedness, he roused the ire, among others, of the American Defense Society, so called, and The Women's International League for Peace and Freedom. It would have been interesting and instructive if both sides had presented their respective cases for whatever they were worth and left the verdict to the intelligence of the public. In so far as the General was concerned, this was done. The "peace" societies, however, played the game not quite so openly, and proceeded to raise a great hue and cry asking that General Fries be silenced. Needless to say the good sense of the Secretary of War declined the invitation.

The point we wish to emphasize is the intolerant tactics of those who differed with the expressed opinion of General Fries. Not content to rebut his views they asked that he be silenced—a return to the old barbarism and intolerance of days past.

It is a strange commentary upon American ideals that fair play is such a rare virtue. It is recalled that once, of old, certain intolerant spirits raised the cry "Crucify Him, Crucify Him." While the twentieth century has more refined methods of punishment—crucifixion has gone as have the pillory and stocks of a later epoch—the spirit which animated the crowd before Pontius Pilate was exactly that exhibited in the present case. Our hope is in an enlightened populace that will know the value of free speech, especially as it applies to friend and foe alike.

General Fries has gained a great victory for adequate preparedness. Let us hope that those who disagree with him or with any advocate of this vital doctrine will play fairly in future and not invoke the customs and instruments of barbarism.

Who's Who In This Issue

Major Lee O. Wright, whose timely article, "A Review of Small Arms Development, 1917-1923," appears in this issue, is especially qualified to discuss all phases of the subject. Major Wright is Chief of the Infantry and Aircraft Armament Division, Manufacturing Service, Office of the Chief of Ordnance.

Major Townsend Whelen, whose article on "Stocks for the Infantry" is published in this issue, is one of the best known and best qualified experts in the United States on all matters pertaining to the rifle.

General Odus C. Horney, the Commanding Officer of Frankford Arsenal, has contributed an effective description of the new "Caliber .30 Armor-Piercing Ammunition, Model 1922."

Lieutenant R. C. Coupland, the author of "The Garand Autoloading Rifle," is an engineer of high repute whose position at Springfield Armory well adapts him to observation of the Garand Gun and the *modus operandi* of its inventor.

Major L. W. T. Waller, Jr., of the United States Marine Corps, has contributed an excellent article on "International Rifle Shooting and the Free Rifle." Major Waller has always been considered one of the foremost leaders in rifle shooting in America.

The article on "Special Features of National Match Rifles" is by Major Stephen H. MacGregor, now stationed at Springfield Amory.

Major R. W. Pinger, the author of "Small Packages from an Engineering Standpoint," is Assistant Ordnance Officer, Philippine Department.

The article on "Mass Production of Small Arms Ammunition," by H. W. Starkweather, is a thoughtful discussion of a vital problem by the general superintendent of The Peters Cartridge Company.

Captain Walter T. Gorton, the author of the paper on "The U. S. Aircraft Machine Gun," is stationed at Springfield Armory where he is thoroughly acquainted with latest developments of the U. S. Aircraft gun.

Mr. Gerald Cahill, whose account of "Our Service Cartridge" should have strong appeal to our readers, is manager of the Lowell Plant of the United States Cartridge Company. He was for many years an ordnance engineer at Frankford Arsenal.

Captain C. H. Morgan, of the Ammunition Supply Division of the Field Service, Office of the Chief of Ordnance, discusses in "The Surveillance of Ammunition" a topic which should prove of general interest.

Mr. L. C. Weldin, of the Hercules Powder Company, author of the article on "Modern Improvements in Small Arms Powders" is a ballistic engineer who ranks high among the "powder confraternity" of the country.

Colonel Thales L. Ames, whose paper, "Captain John H. Hall, His Contribution to the Art of Arms," appears in this issue, needs no introduction to devotees of small arms. Colonel Ames is in command at Springfield Armory and he has had a long and useful record in the Ordnance Department.

Captain Thomas M. Jervey has written an authoritative account of the "Development of Automatic Cannon." Captain Jervey is chief of the Machine Gun Section of the Infantry and Aircraft Armament Division of the Ordnance Office.

Mr. Frederick T. Moore, author of the article on "Machine Guns," is General Works Manager of Colt's Patent Fire Arms Manufacturing Company.

Major Glenn P. Wilhelm is well known to our readers. His article on "Testing Small Arms and Ammunition" shows his customary understanding and knowledge of his subject. Major Wilhelm is Chief of the Small Arms Division of the Technical Staff of the Ordnance Department.

Army Ordnance Index

THERE is forwarded with this issue of Army Ordnance an index to Volume III which is completed with this number. All subscribers who desire indexes to Volumes I and II, which are now in course of preparation, are requested to notify the Secretary, Army Ordnance Association, as soon as possible.

A Review of Small Arms Development

1917-1923

By

LEE O. WRIGHT

DURING the past few years many articles have appeared describing recent developments in small arms and small arms ammunition. This is a field that appeals to the popular imagination, as practically every man in the United States, at some time or other, has possessed some sort of a rifle or pistol and is naturally interested in improvements of arms with which he is more or less familiar.

Many changes have been made in the last five or six years in the equipment of our Army, and weapons and ammunition have been developed to meet requirements previously unthought of. As an example, machine guns before the war were used almost exclusively to supplement rifle fire. They were used at the same ranges as the rifle, and were considered simply as a means by which the soldier could deliver more shots at the enemy in a given length of time than he could with a rifle. Now, as a result of experience gained in the war, we mount machine guns on airplanes; use them on the ground to fire at aircraft with armor-piercing, tracer and incendiary ammunition; and use them for indirect and overhead or barage fire at ranges two or three times greater than was formerly thought possible. These new uses for machine guns have put altogether different requirements on the ammunition, making it necessary to develop new types.

Major Lee O. Wright

In the present article an attempt will be made to give a short review of the development work on each type of equipment, falling under the heading, "Small Arms," since 1917. We take the term, "Small Arms," to include rifles, pistols, machine guns, their ammunition and accessories. At the beginning of 1917 our regular troops were armed with the Springfield rifle, caliber .30, model of 1903; Colt automatic pistol, caliber .45, model of 1911, together with a few each of several different types of machine guns and machine rifles. In this review, each item of equipment will be taken up separately, defects which developed during the war will be pointed out, together with the steps that have been taken to correct these defects, and the new weapons and ammunition which have been developed will be described briefly.

Shoulder Rifles

The number of Springfield rifles on hand at the beginning of the war was so limited that it was necessary to make immediate arrangements to manufacture or purchase numerous quantities to arm our troops. There were only two plants in existence for the manufacture of our standard rifle—Springfield Armory and Rock Island Arsenal. Both plants working to capacity could turn out only a very small percentage of the total number of rifles needed. Fortunately for us, three large plants were manufacturing the British rifle, pattern 1914 for the British Government. The Ordnance Department, after investigating the matter carefully, decided to take over these plants, rechamber the rifle they were manufacturing for our ammunition and use it to supplement the Springfield. This rifle was afterwards known as the U. S. rifle, model of 1917.

A brief discussion of the reasons for adopting this particular course may be of interest. The British rifle as it was then being manufactured could have been taken over and adopted for our army. In that case it would have been necessary to furnish those units armed with this rifle, the British .303 cartridges, and those units armed with the Springfield, the caliber .30 U. S. ammunition. In the opinion of our riflemen, the U. S. cartridge, caliber .30 was much superior to the British cartridge, there being less danger of jams, due to the fact that it has no projecting rim, and in addition, it has a much higher velocity than the British cartridge, and is much more effective at the ranges at which rifle fire is ordinarily used. The fact that both the French and the British have, since the war, made extensive experiments, looking to the development of a rimless cartridge similar to our own, confirms the superiority of the American type ammunition.

Another objection to taking over the British rifle as it was then manufactured was that the parts were not inter-

changeable between the three plants, and, in fact, there was only a limited degree of interchangeability in the product of any one plant. With the war being fought so far from home, interchangeability of all parts was a prime necessity for the successful repair of arms damaged in action. In fact, the greater part of the delay in the delivery of rifles when we took over the plants was occasioned by this necessity of securing interchangeability, and not by the rechambering of the gun for our ammunition.

The second alternative, that of manufacturing the Springfield rifle exclusively, would have delayed production of rifles for at least twelve months. This, at a time when certain very influential citizens were denouncing the Ordnance Department for not supplying arms for training, stating that our soldiers had to drill with broom sticks, would have been fatal. As it was, the sailing of troops was not delayed in any instance due to lack of rifles, other reports to the contrary notwithstanding.

During the war both rifles gave a good account of themselves. In the opinion of most riflemen, the model of 1917 had one marked superiority over the Springfield—its large aperture sight located on the receiver near the eye. The sight, however, lacked one feature that has endeared the Springfield to the expert rifle shot. It could not be moved laterally for setting of windage. The advantage of the sight was more than offset by certain other disadvantages. The rifle weighed more than the Springfield and its bolt action, cocking on closing, made it necessary to push the bolt home more forcibly than with the Springfield. It was a common report that if the soldier had a chance, he would throw away his 1917 rifle and pick up a Springfield.

After the war it was decided to retain the Springfield in service, and put the 1917 rifle in storage for use in emergency. We may say that the war showed that our Springfield rifle stands at the top of all military bolt action rifles.

Receiver Sights

As stated before, the 1917 had a sight close to the eye. The advantage of this type of sight in quick shooting and in training troops led to a determined effort to get such a sight for the Springfield rifle, improving it, however, by adding a windage adjustment. Various types were tried out, and finally, the three which showed the most promise were submitted for test. Twenty-five sights of each of these three types were attached to rifles and sent to the Infantry Board for test. All of these sights have windage and elevation adjustments, the smallest reading in each case being one minute. While these sights have been under test by the Infantry for nearly three years, no report has as yet been received.

The desirability of a receiver sight is almost universally admitted. Its attachment to the present rifle, which was not designed for such a sight, is extremely difficult. However, the success that has been obtained in the development of a semi-automatic rifle renders it unlikely that a serious effort will now be made to equip our present shoulder rifles with such a sight.

Telescopic Sights

During the war there was a demand for a large number of rifles fitted with telescopic sights. Our standard sight was the Warner & Swasey telescopic musket sight, model of 1913. A number of these were purchased and used during the war, but they proved rather unsatisfactory under service conditions. This sight is mounted on the side of the rifle, causing the riflemen to assume an unnatural position. Its power is too high and the field of view too small, and, in addition to the above disadvantages, it gets out of adjustment very easily, due to shifting of the prisms.

During the war a telescopic sight was developed by the Winchester Company of 2.6 power. This sight was very similar to the standard Winchester 5A commercial sight, except that it was much shorter. Difficulty in getting orders placed prevented the production of any of these sights prior to the Armistice. This was really fortunate, as the sight has since been tested at Fort Benning and reported on as thoroughly unsatisfactory. Efforts are still being made to develop a suitable telescopic sight for use by snipers.

Miscellaneous Development Work

With the exception of the sights, very few attempts have been made to improve the Springfield rifle. After a series of tests, the Infantry Board recommended that the present length of stock be retained. Stocks with pistol grips have been tested and reported on, in general, favorably, but it is unlikely that any attempt will be made to modify our present rifle. If a semi-automatic rifle is adopted, it no doubt will have a pistol-grip stock. Several novel features, such as the relaxing trigger which fired on releasing the pressure on the trigger, and the thumb trigger which was located so that the piece could be fired with the thumb, have been tried out and reported upon unfavorably. Reference to the semi-automatic rifle will be made later.

U. S. Rifle, Caliber .22, Model of 1922

Before the war we used for preliminary target practice caliber .22 short ammunition fired from a regulation Springfield with a .22 caliber barrel. The cartridges were held in steel holders of the same general shape as the regular caliber .30 cartridge. It was practically impossible to obtain accuracy with this weapon and the system was abandoned during the war. In 1919 we adopted the plan of reloading caliber .30 ammunition for firing at reduced ranges. Reloading outfits were manufactured and issued to the various posts, and reloading was done by the enlisted personnel. A reduced charge of powder was used and cartridges were loaded with a 140-grain lead bullet. These reloading outfits have not proved as successful as was anticipated, and it is expected that, when the supply of components on hand is used up this method will be abandoned. To take its place, Springfield Armory has developed a caliber .22 rifle very similar to the standard Springfield, which fires the .22 caliber long rifle cartridges. This rifle is extremely accurate up to 200 yards. Arrangements are being made to supply a limited number to each organization equipped with the rifle. Springfield Armory deserves great credit for the design of this remarkable weapon.

Caliber .45 Pistol

As with the shoulder rifle, the war confirmed the good opinion we had of the caliber .45 pistol. However, lack of manufacturing facilities made it necessary to purchase a large quantity of caliber .45 revolvers—Colt and Smith & Wesson. These revolvers were used during the war but are now being put in storage as a reserve. No defect of any importance developed with the pistol, and except for experiments with different types of front sight and a few minor modifications, no development work has been done along this line. It appears that the Colt automatic pistol, caliber .45, will be a standard weapon for a long time to come.

Caliber .45 Blank Attachment and Caliber .22 Attachment for Caliber .45 Pistol

Two modifications in the pistol have been made by

Springfield Armory, but they have not yet proved successful.

The first is a blank attachment to enable blank cartridges to be fired automatically. To fire blank ammunition, the standard barrel is replaced by another barrel which has a small opening in the muzzle end. When the blank cartridge is fired it builds up enough pressure to cause the gun to operate. As a safety precaution, a special blank cartridge is used and the barrel is chambered for this special cartridge, it being impossible to insert a ball cartridge. This work has not yet been carried to a successful conclusion, the principal difficulty being to secure a specially shaped blank cartridge which will function satisfactorily in the standard magazine.

The second modification which promises more chance of success is an attachment for the caliber .45 pistol which enables it to fire automatically with caliber .22 long rifle ammunition. In this case the barrel and slide are replaced by a fixed slide, which contains the caliber .22 barrel and semi-automatic mechanism. It is necessary, of course, to use a special magazine.

Ground Machine Guns

At the time we entered the war we had on hand a total of approximately 1,300 machine guns of various types—the Benet-Mercie, Colt, Maxim, Vickers and Lewis—the latter firing British ammunition.

In 1915, as a result of test, the Vickers machine gun was adopted by our service and a small order placed for its manufacture. None were delivered up to the declaration of war. In the spring of 1917 another test of machine guns was held, and a new weapon was submitted by Mr. Browning. The result of this test proved conclusively to the Board that was conducting the test that the new gun was much superior to the other types of machine guns, and accordingly it was adopted as our standard weapon. This gun is recoil operated and water cooled. While only a limited number of these guns reached the front, its performance as a machine gun was considered very satisfactory. Certain very serious criticisms were made in regard to the range of this gun as compared to the French and German machine guns, but as this is a matter which relates almost entirely to ammunition, it will be discussed later. One rather serious defect developed, the bottom plates were not sufficiently strong, but these have been reinforced and no longer give trouble. It has not been possible to get the accuracy with this gun that can be secured with some other types of machine guns, due in part to the movement of the barrel, and in part to the very poor tripod which we have.

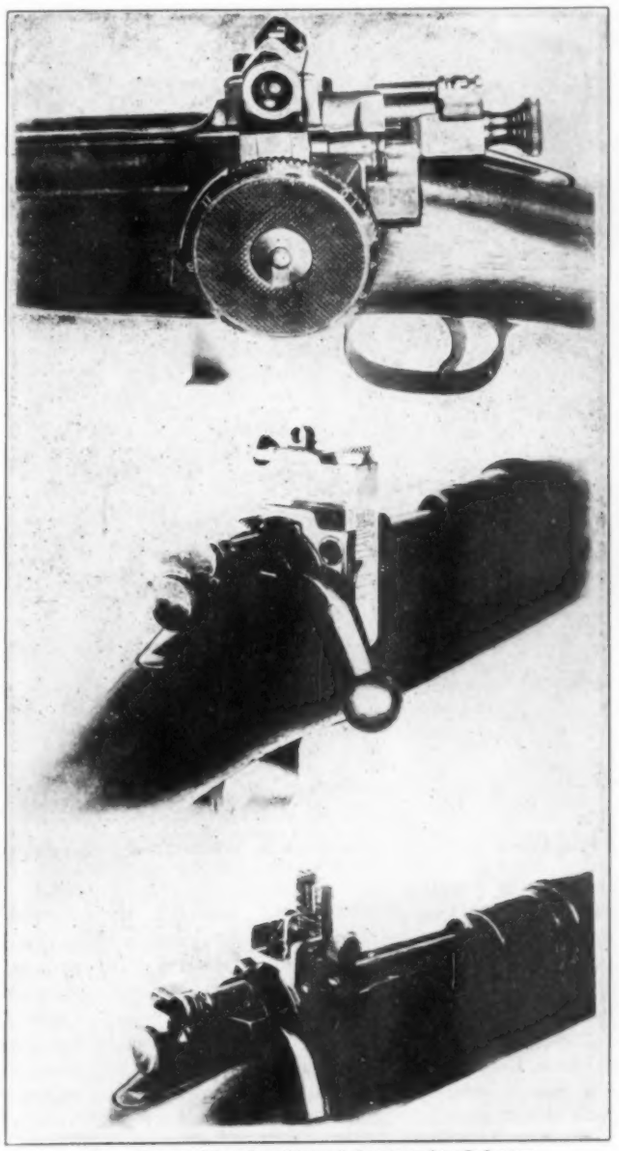
Machine Gun Tripods

There are two tripods for this weapon—the model of 1917 and the model of 1918 tripod, neither of which are considered satisfactory. Of the two, however, the 1917 is preferred by most organizations. The Ordnance Department has spent quite a bit of money attempting to improve these tripods, but has finally come to the conclusion that the making of extensive improvements in this material would be practically a waste of money, and is devoting itself to attempting to design a satisfactory tripod for future manufacture. The Infantry requirements for a tripod are as follows:

> The tripod should be as light as practicable, and in no case should weigh more than fifty pounds. It should be rigid enough to permit direct, indirect and overhead fire. The traversing and elevating mechanism should be simple and capable of being set accurately. The least reading of the elevating mechanism should be one mil, and the least reading of the slow motion traversing mechanism should be two and one-half mils. It should be possible to get an elevation of 400 mils with the tripod on a level surface. It should be arranged to permit the attachment of an anti-aircraft adapter to give overhead fire.

Machine Gun Panoramic Sight

Another war-time product was the panoramic sight, model of 1918. In this sight an effort was apparently made to include everything that had been found desirable in a sight of this type for a field gun. The result was a heavy, unwieldy sight, which had to be removed from the machine gun every time the gun was fired. This sight has proved unsatisfactory and it will be necessary to design a lighter and more compact sight, even if some of the refinements are left off. Many infantrymen doubt the need of such a sight.



Three Types of Receiver Sights being tested by Infantry
Upper: Nash Receiver Sight
Center: Lyman Sight No. 48 modified
Lower: Hatcher Receiver Sight

Summing up, we may say that the Browning machine gun has proved satisfactory in most respects. The tripod and panoramic sight have proved unsatisfactory, and two of the problems before the Department now are the design of a tripod which will meet present requirements and the design of a simpler sight.

Automatic Rifles

In British, French and German tactics three types of weapons firing small-arms ammunition were recognized and used—the rifle, fired from the shoulder; the machine gun, fired from a fixed mount, and the machine rifle. The latter is a portable arm which can be carried forward by front-line troops, and, in case of necessity, fired from the hip. It is generally fired, however, from a prone position, the muzzle being supported by a light bipod. The French used the Chauchat; the British the Lewis, and the Germans the Maxim '08-15. A number of our troops were armed with the Chauchat, which was not found very satisfactory.

Above: Caliber .45 Automatic Pistol
Below: Caliber .45 Automatic Pistol, Modified to Fire Caliber .22 Long Rifle Cartridges

To take the place of the machine rifle we adopted a new weapon—the Browning automatic rifle. It was not produced in time for many of these weapons to reach the front, so that it cannot be said to have been given a real test under war conditions. This weapon was hailed with great enthusiasm at the time it was brought out as being one of the most remarkable arms yet produced. This enthusiastic opinion has been somewhat modified in the last few years. In the design of the weapon an effort was made to produce the lightest automatic gun which would function with our ammunition. The result, while securing a very light weapon which functioned reliably, was not entirely satisfactory. As it stands now the weapon is neither light enough to be used as a shoulder weapon nor heavy enough to be used as a light machine gun or machine rifle. When an attempt is made to fire it automatically it is impossible to hold on the target. This defect is so apparent that serious consideration has been given to removing the automatic feature entirely, making it possible to fire it semi-automatically only. The barrel is so light that it is impossible to fire the weapon for any length of time without putting it out of action, due to heating.

Machine Rifle

Since the war the automatic rifle has been redesigned by adding a much heavier barrel and a bipod mount, converting it into a machine rifle. The sight has also been redesigned in order to give windage adjustment. This weapon, which weighs about 21 pounds, will give three times the sustained fire power of the Browning automatic. The machine rifle has been officially adopted by the Cavalry, and the Ordnace Department is modifying a sufficient number to take care of the needs of that service.

Blank Firing Attachments

For use in maneuvers, etc., blank firing attachments for the Browning machine gun, Browning machine rifle and Browning automatic rifle have been designed to enable these guns to function with blank ammunition. The Germans accomplished this with their machine guns by using ammunition loaded with hollow wooden bullets. We use the standard blank ammunition without bullets and fasten an attachment on the muzzle which reduces its diameter to about one-eighth of an inch. With this small opening the blank cartridge will build up sufficient pressure to operate the weapon automatically. Safety attachments are placed on the guns to prevent a loaded cartridge to be fired while the blank ammunition attachment is on the muzzle.

Aircraft Machine Guns

While we were fortunate enough to secure a satisfactory ground machine gun at the beginning of the war, we were not so fortunate in regard to machine guns for aircraft use. Two types of machine guns are used on airplanes. The synchronized gun for the use of the pilot is rigidly attached to the plane and fires directly to the front. To prevent bullets striking the propeller, a synchronizing gear is attached to the gun and motor which does not permit the gun to fire when the propeller blade is in line with the bore. The flexible or free gun is mounted in the rear and is used by the observer. At the beginning of the war we had no aircraft machine guns and our first planes were armed with foreign guns—the Vickers for the use of the pilot and the Lewis for the observer.

As a synchronized gun we adopted the Marlin aircraft machine gun for manufacture and a large number were produced. This gun, while it appeared to be the best available at the time, has proved quite unsatisfactory and is now considered as a reserve weapon for emergency use only. Even when carefully adjusted, the Marlin gun would fire only carefully selected ammunition—ammunition of a much higher grade than could reasonably be expected in war-time production. It was necessary in order to secure ammunition which would function in this gun to fasten in the primers to prevent them from blowing out by crimping the metal over the primer cup, and to give the ammunition for aircraft use, special inspection to eliminate any possible defects which would not cause trouble in other types of machine guns. This specially selected ammunition was packed in cartons and marked for aircraft use only.

The defects of this gun being apparent, the next step was an attempt to modify the Browning machine gun for aircraft use. This modification consisted principally of lightening of parts, the elimination of the water jacket, and the development of a trigger arrangement to enable it to function with the standard synchronizing gear. This gun, known as the Browning aircraft machine gun, model of 1918, born under war-time conditions without sufficient experimental work being done and without being tested sufficiently, also proved unsatisfactory, and one of the first projects after the war was to rebuild the guns at practically the cost of manufacturing new guns, so they would function more reliably. The Air Service is now armed with this gun which is known as the Browning aircraft machine gun, model of 1918 MI. It is not considered entirely satisfactory. The Browning aircraft machine gun, model of 1919, which is practically the 1918 Mark I on a manufacturing basis, has been designed and a number are now being manufactured.

In addition to these types the Ordnance Department has developed at Springfield Armory, the U. S. aircraft machine gun, model of 1922, which, while embodying a number of the Browning principles, has been so designed as to feed from either the right or left hand side. This gun is described elsewhere in this issue.

At the present time the Browning aircraft machine gun, model of 1919, is considered our standard synchronized machine gun for future manufacture. It is not an ideal gun but is considered fairly satisfactory. It may be that the desirability of having a gun which will feed from either the right or the left hand side will lead either to the adoption of the U. S. machine gun, model of 1922, or to the design of a gun similar or identical with the Browning machine gun, model of 1919, with the exception that it will feed from the right-hand side instead of the left-hand side. In the latter case the right-hand feed gun will be mounted on one side of the plane and the left-hand feed gun on the other.

We adopted the Lewis gun, chambered for our ammunition, as a free gun. That gun was used during the war and is still the standard arm for this purpose. Serious consideration is being given to the use of the Browning aircraft machine gun as a free gun. The successful use of this gun by the observer depends on the development of a satisfactory magazine for holding the cartridges. Several designs have been made and some of them show promise. This project has been given priority and it is hoped that magazines will be produced for service test within a short time. The desirability from a supply standpoint of having one type of caliber .30 gun for Air Service is very great. Whether or not this can be accomplished will depend upon the results of tests.

Caliber .30 Anti-Aircraft Machine Guns

The standard Browning machine gun, water-cooled, is also used as an anti-aircraft gun. Adapters have been provided for the 1917 and 1918 tripods, which enable this gun to deliver high-angle fire. These adapters are heavy and are not considered satisfactory, although they can be used in case of emergency.

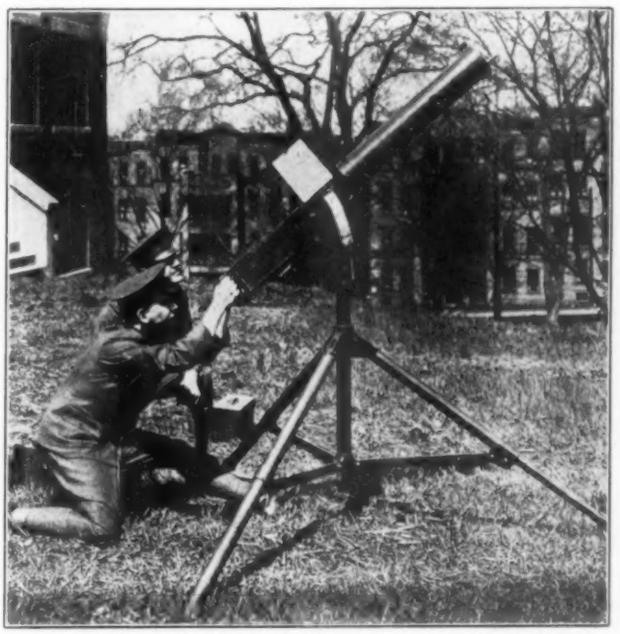
The anti-aircraft tripod, model of 1918, was also designed, primarily, for anti-aircraft use. This is another wartime product and has proved unsatisfactory. No more will be made. Some experiments have been conducted, looking to the development of a more satisfactory anti-aircraft tripod, but due to the apparent success of the caliber .50 machine gun as an anti-aircraft weapon, described later, this project has not been pushed.

Caliber .30 Tank Machine Gun

Our tanks are equipped with an air-cooled, heavy Browning machine gun. This gun has proved satisfactory and no effort is being made to develop another gun.

Caliber .50 Machine Gun

There have been numerous articles written on our .50 caliber, so-called "super machine gun." The Browning machine gun having proved so successful when firing caliber .30 ammunition, an effort was made in the early part of the War to design a gun which would fire a larger cartridge. As a result of this work the .50 caliber machine gun was produced to fire a cartridge with a muzzle velocity of approximately 2,450 f. s. The bullet weighed about 600 grains. While we were patting ourselves on the back at having produced such a remarkable weapon, a few German "elephant" guns were captured, together with some 13 mm. ammunition. It was found that the Germans were getting a muzzle velocity around 2,500 f. s. with an 800-grain bullet, and, not to be outdone, we immediately increased the requirements of the .50 caliber, and eventually, some time after the War, the present .50 caliber machine gun was produced, which fires an 812-grain bullet at a muzzle velocity of 2,600 f. s. The gun is very similar to the caliber .30 Browning, with the exception that an oil buffer has been added to help absorb the excess energy developed by the much more powerful gun.

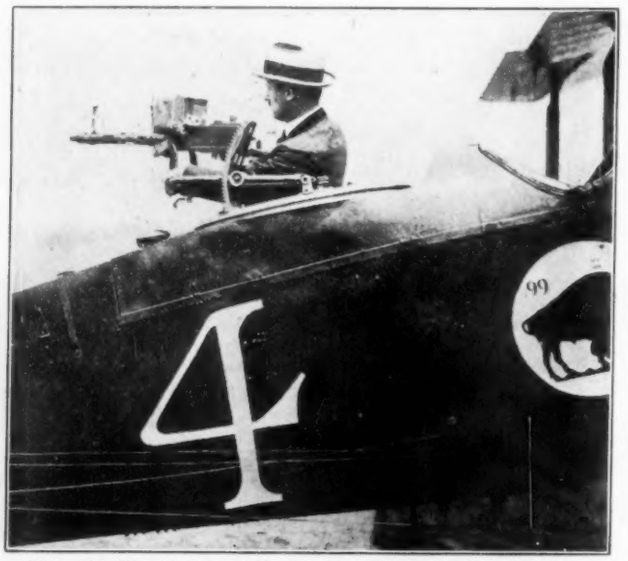


Caliber .50 Browning Machine Gun Mounted on Anti-Aircraft Tripod

The first .50 caliber guns produced were the water-cooled, ground type; the air-cooled, aircraft type; and the air-cooled, anti-aircraft and tank type. In tests by the Infantry it has been found that it is extremely difficult to keep the gun on the target when fired automatically, as the energy developed is so great that it is practically impossible to hold the gun down for horizontal fire with a light tripod. The weight of the gun and tripod, about 160 pounds, makes it extremely difficult to transport by hand. For these reasons, as an Infantry gun, the weapon has not met with approval. It has also been decided that there is no particular use for this type of gun in the armament of the tank. The aircraft gun has proved very successful and

the gun has been adopted by the Air Service as a synchronized weapon. There is every reason to believe that the .50 caliber gun will prove to be one of our most successful weapons for this purpose.

The anti-aircraft gun was originally designed with a 30-inch barrel. When tested it was found that with this short barrel the muzzle flash was excessive. The water-cooled gun was tested for anti-aircraft use at the same time and has proved more satisfactory than the anti-aircraft gun, and recommendation has been made to the Ordnance De-



Browning Flexible Aircraft Machine Gun, Caliber .30, Model 1919, with Experimental Magazine, Rear View

partment that the water-cooled gun be adopted as standard for anti-aircraft use. This gun will fire a cartridge which has a maximum range of approximately 9,000 yards. The armor-piercing bullet will penetrate one inch of armor plate at short ranges, and the tracer bullet will give a vivid trace for at least 2,500 yards.

An anti-aircraft tripod has been designed for this gun which is apparently quite satisfactory, except for the fact that having been designed for the aircraft gun, the trunnions are located too far to the rear, so that when the water-cooled gun is used the gun tips forward. Effort is now being made to redesign the cradle to overcome this defect.

Semi-Automatic Rifles

One of the most important projects before the Ordnance Department today is the development of a semi-automatic rifle. For twenty-five years this country and practically all foreign countries have been attempting to get such a weapon.

With the present rifle, after each shot is fired, it is necessary to take the hand from the trigger and open and close the bolt, ejecting the fired case and inserting a new cartridge. In a semi-automatic or self-loading rifle, the fired case is ejected and a new cartridge inserted automatically. All the rifleman has to do is pull the trigger each time he wishes to fire.

Before the war we had constructed several models but they were all of a very complicated nature, heavy and unreliable in their functioning. During the war, when funds for experimental work were plentiful, a great deal of work along this line was done. Seven models were made, operating on different principles, but none would function satisfactorily. Since the war experimental work along this line has continued. Each year, with the exception of 1922, the specifications for this type of rifle were sent to all interested American designers and a competitive test was held at Springfield Armory by a Board appointed by the War Department to determine if any of the guns submitted were practicable. At the last test four guns were submitted; one designed by Mr. Garand, described elsewhere in this issue; one designed by General Thompson and manufactured by the Auto-Ordnance Corporation; one designed at Springfield Armory; and one somewhat on the principle of the Berthier machine gun submitted by the United States Machine Gun Company. While all of these guns would function, no gun showed sufficient promise to warrant its adoption. Since then various improvements have been made, and the Ordnance Department has purchased twenty Thompson auto-loading rifles and has directed the manufacture of twenty-four Garand rifles for test by the using services.

The designer of a semi-automatic rifle for our service ammunition is up against a very difficult problem. He is expected to design a weapon that will fire semi-automatically a cartridge developing a pressure of 52,000 pounds per square inch, and at the same time must keep the weight of the arm practically the same as the present service rifle. The weight limit makes it practically impossible to construct such a weapon, utilizing the commonly accepted methods of obtaining automatic or semi-automatic action: *i. e.*, blow-back, recoil or gas operation. In the article on the Garand gun in this issue, Captain Coupland describes how the desired result is accomplished. In the Thompson gun the locking lugs are set at an angle, and it is claimed that the bolt will not turn under the high pressure developed by the caliber .30 cartridge, 52,000 pounds, but will turn when the pressure is reduced considerably. With this gun, to secure uniform functioning, it is necessary to oil the cases of the cartridge, which is accomplished by oil pads on either side of the magazine. Both the Thompson gun and the Garand gun are heavier than the present service rifle, but both have well-developed action.

If the service test of either of these guns is satisfactory, two problems will be presented: First, the difficulty of securing a sufficient ammunition supply to utilize the guns to the best advantage, and second, the excessive heating of the barrel which will be caused by firing rapidly. A number of authorities on small arms believe that these disadvantages, which are inherent in this type of weapon firing our service cartridge, are of sufficient importance to warrant serious consideration being given to the development of a rifle of this type, firing a lighter ammunition with considerably less breech pressure.

From the knowledge we now have it appears practicable to design a semi-automatic rifle within the weight limit of the present Springfield, if we adapt it to fire a cartridge of slightly less power than our standard ammunition. In this case the cartridge would weigh less, more ammunition could be carried and the heating effect from continuous firing would be greatly reduced. To offset these advantages we have a more curved trajectory, a bullet which would be affected more by the wind, and a considerably shorter range. The last objection, however, is thought to be relatively unimportant, as the present service cartridge has considerably more range than can be used by the riflemen.

In order that the using services may have before them such a rifle to test in comparison with the ones which are now being manufactured or purchased, the design of a semi-automatic rifle with the following characteristics has been approved:

Weight—not over 8 pounds.
Caliber—as near caliber .30 as possible, and in no event below 7 mm.
Weight of bullet—approximately 125 grains.
Weight of cartridge—285 to 300 grains.
Muzzle velocity—as near 2,500 feet per second as possible.
Pressure—not over 42,000 pounds per square inch.

It is generally recognized by all that the next important step in small arms will be a light semi-automatic rifle to take the place of the present bolt-action rifle. If such an arm is adopted it is reasonable to suppose there will be no place for the present Browning automatic rifle.

37 mm. Gun for Aircraft and Anti-Aircraft Use

The 37 mm. hand-operated cannon was used very successfully during the war as an anti-aircraft weapon by the Allies. The value of this weapon for that purpose would, of course, be greatly enhanced if it could be made to fire automatically or semi-automatically, as the length of time which a target is in range is very limited. Several models of automatic or semi-automatic 37 mm. cannon have been designed, but so far none that has been produced can be considered as sufficiently reliable. Another important use for the 37 mm. automatic cannon is on the airplane in order that the plane may carry a weapon firing a heavier projectile than the caliber .30 or caliber .50 machine gun. Hand-operated cannon are already carried by airplanes, but their value would be greatly increased if they could be fired more rapidly. The aircraft weapon must, of course, be made as light as possible and the shock of discharge reduced to a minimum.

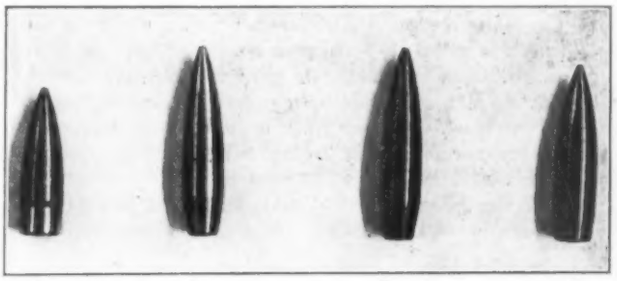
A study is being made of the .50 caliber machine gun with a view to utilizing the principles of this gun in the construction of a machine gun to fire 37 mm. ammunition. This study has not progressed far enough to permit predictions to be made as to its ultimate success. If a weapon can be designed which will fire a high-velocity 37 mm. shell, either automatically or semi-automatically, it should prove very successful as an anti-aircraft weapon. An article in this issue of ARMY ORDNANCE by Captain Jervey on automatic cannon should be noted in this connection.

Caliber .30 Ammunition

At the beginning of the war we were very well satisfied with our rifle and machine-gun ammunition. We prided ourselves on being a nation of rifle shots, and as our riflemen were satisfied with our ammunition we considered it as near perfection as possible to make it.

We had actually had very little experience with machine guns and considered them merely an auxiliary arm to increase the fire power of our riflemen. Nobody ever fired at ranges beyond 1,000 or 1,200 yards, and our ammunition was certainly satisfactory up to that range. Range tables prepared from data secured from these short-range firings showed that we had a maximum range of practically 4,500 yards. When reports began to come back from the A. E. F. that our ammunition was not satisfactory and did not have sufficient range, and that the French and British ammunition, as well as the German machine-gun ammunition, outshot it by more than a thousand yards, we were naturally somewhat disturbed and skeptical.

In order to check these reports a small-arms range was established at St. Jean de Monts, France, and another at Miami, Fla. Comparative firings of various types of small-arms ammunition at these two places conclusively proved that our ammunition was not designed for long-range work. Request was made by the A. E. F. that we attempt to improve our ammunition in this respect by increasing the weight of the bullet and by putting a taper on the base, or a "boat-tail," as it was commonly called. A few thousand bullets were secured from the Swiss and forwarded to this country, with the recommendation that a bullet be designed along the general lines of the Swiss bullet. When we fired the Swiss ammunition we found that its extreme range was almost 2,000 yards greater than our own and its accuracy very good. An experimental lot of bullets was made at Frankford Arsenal, following as closely as possible the Swiss bullet. When these bullets were loaded into cartridges and tested it was found that we had increased the range of our ammunition very materially, but as might be expected, the accuracy was very poor. The bullet as at first made was more pointed than our present service bullet, so it was necessary to have rifles specially chambered for this bullet in order to get the best results.



1. Standard Caliber .30 Bullet, weight 150 Grains, Flat Base
2. Standard Swiss Bullet, weight 174 Grains
3. 175 Grain Boat-Tail Bullet, Caliber .30
4. 170 Grain Boat-Tail Bullet, Caliber .30

During the past four years various types of bullets have been tested, but it can be said that we have not yet finally determined which is the most satisfactory. We have made up bullets weighing from 150 to 220 grains, both flat base and boat tail, and have fired them at various velocities. So far the bullet which has showed the most promise has a boat-tail with a 6 degree taper, weighs approximately 170 grains and has the service ogive. One of the principal difficulties with this ammunition has been to get accuracy. That it was not inherently impossible to make accurate ammunition with a boat-tail we knew, as the Swiss won the International Matches some years ago, using this type of ammunition. It was purely a question of balancing the bullet properly, refining manufacturing methods and determining the proper hardness of the core and jacket. With the bullet just described we have apparently solved most of these difficulties, as it is remarkably accurate at all ranges, comparing very favorably with the most carefully made flat-base bullets. While it has a much greater range than the service ammunition, it does not, however, equal the Swiss in that respect. Efforts are still being made to increase the range without affecting the accuracy.

It might be said for the benefit of those who have not read the articles which have appeared recently about boat-tail bullets that the boat tail has very little, if any, effect at high velocity, but as soon as the velocity of the bullet drops below 1,200 feet per second it appears to eliminate to a large degree, the drag caused by the vacuum at the base of the bullet. This has the effect of straightening out the latter part of the trajectory.

The Infantry have stated that they wish an ammunition which has the longest possible range and the flattest possible trajectory. A flat trajectory, however, is not entirely without its disadvantages. For one reason, in overhead fire it prevents our troops approaching as closely to the

objective as they can with ammunition giving a more curved trajectory.

In one other respect we have been attempting to make our ammunition more satisfactory. For many years practically all military bullets consisted of a lead core covered with a cupro-nickel jacket. One notable exception is the French ammunition, which is loaded with a solid brass bullet. Rifle barrels in which a bullet with a cupro-nickel jacket is fired are liable to become coated with patches of metallic fouling, which seriously affects accuracy. This fouling is more liable to occur in case the bore of the rifle is slightly rough. It has been necessary to issue metallic fouling solution for the removal of this, which is not a difficult operation if performed properly, but which gives great trouble in the field. In order to overcome difficulties caused by this metallic fouling several experiments have been conducted. One was to incorporate a small amount of tin in the powder. This method was only fairly satisfactory. Another method which was thought by some people to solve the difficulty was to plate the bullet jackets with a thin coating of tin. It was claimed that this would completely eliminate metallic fouling. The National Match ammunition of 1921 was loaded with a bullet treated in this way. The claims that metallic fouling would be eliminated were apparently borne out, but even under the conditions encountered at the National Matches it was found that another difficulty arose which was considered worse than metallic fouling. The tin itself fouled the rifle barrels to such an extent as to necessitate very frequent and laborious cleaning. After the National Matches of that year this type of ammunition was abandoned.

During the past two years extensive experiments have been made with a jacket metal composed of 90 per cent copper and 10 per cent zinc, known as gilding metal. When this is properly worked to secure the right degree of hardness a very satisfactory bullet jacket metal is obtained. From present indications it appears that the use of this type of bullet-jacket material is advantageous, although the Ordnance Department is not yet prepared to make a definite recommendation on this point, believing that it is well to test out new departures from standard practice, such as this, very extensively before actually committing itself.

Caliber .50 Browning Machine Gun in Action

Caliber .30 Tracer Ammunition

The tracer bullet is one of the outstanding developments of the past six years. This is a bullet, the interior of which is filled with an inflammable substance, which is ignited when the cartridge is fired. It burns with a bright flame and enables the course of the bullet to be followed. At the beginning of the War we had done no experimental work whatever on this type of ammunition. A few months after our declaration of war we sent an observer to England and France to observe their methods of manufacture of tracer and incendiary ammunition. Upon his return we designed a caliber .30 tracer bullet similar to the British bullet, using the same tracing mixture, *i. e.*, barium peroxide and magnesium. Several millions of these cartridges were manufactured and were used during the war. These bullets would trace for a distance of approximately 800 yards. The accuracy, however, was extremely poor, and the need for further development was apparent.

Since the war we have been experimenting with this ammunition, trying to secure a tracer bullet which would meet our requirements. Our specifications for the development of this ammunition call for a trace of 1,500 yards. Frankford, within the last year, has been able to produce tracer bullets which will trace about 1,400 yards with a vivid flame. Unfortunately, however, our tests show that they function only about 80 per cent of the time. Apparently this can be overcome by more care in manufacture and a study of the problem will be continued until we produce a satisfactory tracer bullet.

Two types of tracer bullets have been developed; one tracing with a red flame, the other with a white flame. The tracer bullet is now used by the Infantry for instructional purposes and to designate targets. For aircraft and anti-aircraft work, the use of the tracer bullet has been found to be the most effective means of directing machine-gun fire. From the nature of the targets presented it is very difficult to use any type of sight, but by actually seeing where the bullets are going the cone of fire can be directed on the target.

Caliber .30 Incendiary Ammunition

As with the tracer, we adopted the British incendiary type of bullet. This bullet was used for firing at balloons, etc., with the hope of bringing them down in flames. The efficiency of this type of bullet, which contained phosphorus, has apparently been over-estimated. The bullet has a slug of phosphorus in the nose, and a small opening in the jacket, sealed with solder of low-melting point. The heat developed when pasing through the bore melts the solder and allows the phosphorus to come in contact with the air, which ignites it. The phosphorus will burn for 300 or 400 yards, but the flame is so small that it is doubtful if such a bullet is much more effective in causing fires than the standard tracer. In fact, at a test at Essington in 1918, it was found that it was necessary to fire a large number of these bullets at an eight-foot balloon filled with hydrogen gas before it could be ignited. At the same range one 11 mm. tracer cartridge was fired and the balloon burst in flames. It has been found that this incendiary ammunition, because of its chemical composition, cannot be stored, and all stocks manufactured during the war have been disposed of.

Armor-Piercing Ammunition

At the beginning of the war we had an armor-piercing bullet which had been developed at Frankford Arsenal, called the armor-piercing bullet, model of 1917. This bullet was composed of a hardened steel core weighing 65 grains, a lead envelope and a cupro-nickel jacket. The nose of the jacket was open, allowing the lead point to protrude. These bullets were found to be very little more effective than a bullet in which the jacket covered the point, and accordingly this type of ammunition was discarded, and our armor-piercing bullet, model of 1918, substituted in-

stead. This bullet also has a 65-grain steel core, lead envelope and cupro-nickel jacket. The accuracy of this ammunition was poor and its armor-piercing qualities not very great. Extensive experiments have since been made and we have developed the present armor-piercing bullet, model of 1922, which has an 87-grain core. The total weight of bullet is 168 grains. This ammunition is extremely accurate and its armor-piercing qualities are remarkable, penetrating .6 inch of armor plate at short range, and making clean-cut penetrations of one-quarter inch plate at 500 yards. The principal use for this type of ammunition is against airplanes, the vital parts of which can be protected with thin armor plate which will resist penetration by the ordinary service bullet.

Caliber .50 Ammunition

Mention has been made before of the caliber .50 machine gun. Extensive experiments have been conducted looking to the development of the best possible type of ammunition for this gun, but so far we are not satisfied that we have produced the best that it is possible to get. The ammunition which shows the most promise gives a muzzle velocity of approximately 2,600 feet per second, firing an 812-grain bullet. This bullet has a steel core very similar to the caliber .30 armor-piercing bullet. Tests have been made which show that with this bullet we are able to penetrate one inch of armor plate at short range. This ammunition does not have the accuracy which we desire and further experiments are being conducted along this line.

In this short review no effort has been made to go very much into detail, and only the major items have been touched upon. To describe all of our experimental work in the past five years would require a volume several times the size of ARMY ORDNANCE. It may be said, however, that more experimental work has been done and greater results have been obtained in these few years in the realm of small arms than has been accomplished in a like period of time in the history of our country. The outstanding developments in this field are:

First.—The perfection of the machine gun and particularly the change in tactics which its extensive use has brought about;

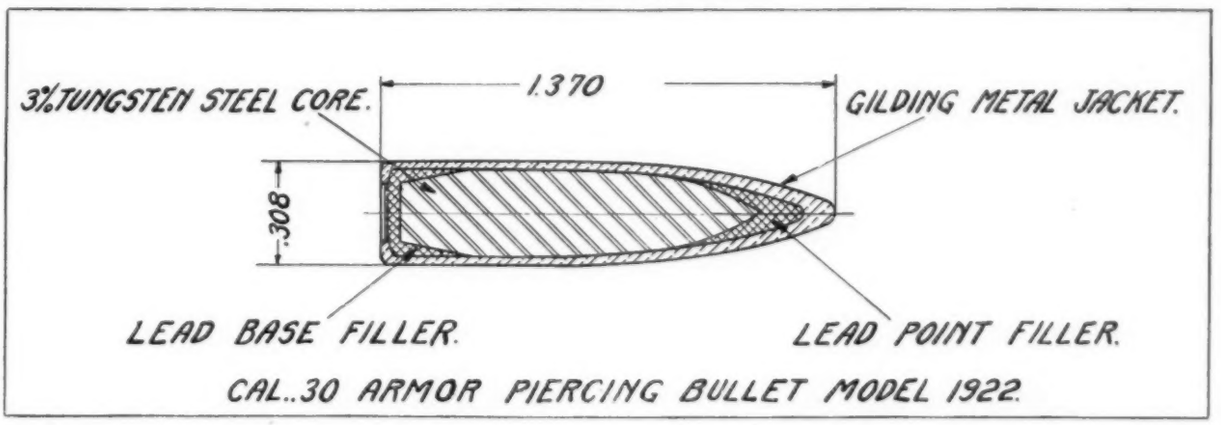
Second.—The improvements in our standard ammunition which have been necessary to meet requirements which were not thought of at the time the ammunition was designed;

Third.—The development of the .50 caliber machine gun, and the effect which it is sure to have as an anti-aircraft weapon;

Fourth.—The development of armor-piercing and tracer bullets for small-arms ammunition, a possibility that was formerly overlooked.

Caliber .30 Armor-Piercing Ammunition

By ODUS C. HORNEY



THE present type of caliber .30 armor-piercing ammunition, Model 1922, was adopted after a long series of experiments.

The caliber .30 armor-piercing bullet, Model 1918, with its steel core having a very sharp point, gave good penetration at normal impact, but when fired at an angle of impact at forty-five degrees, it was found that this sharp point lacked the necessary strength to give good penetration.

This bullet also was subject to the weakness of "stripping" its jacket, probably due to its length, combined with the fact that it was impossible to secure a perfect fit between the core and the jacket.

These difficulties lead to the adoption of a steel core having a radius of two calibers in length; the forward end of the jacket being filled with a lead cap. Tests of this bullet, both at the Frankford Arsenal and the Aberdeen Proving Ground, gave such favorable results that it was finally adopted for use.

The bullet consists of four parts: (a) the jacket, (b) the steel core, (c) the lead point-filler, and (d) the lead base-filler, as shown in the accompanying illustration.

The jacket is made of gilding metal, which is an alloy of ninety per cent copper and ten per cent zinc, and weighs 58.0 grains, plus or minus 0.5 grain.

The core is made of three per cent Tungsten steel, heat treated and weighs 87.5 grains, plus or minus 1.0 grain.

Both the point-filler and the base-filler are made from an alloy of thirty-nine parts lead and one part antimony, and weigh 9.75 grains and 12.75 grains respectively, with an allowed variation of plus or minus .025 grain in each case. The assembled bullet weighs 168.0 grains, plus or minus 2 grains.

The caliber .30 armor-piercing ammunition, Model 1922, has an initial velocity of approximately 2,700 f. s., with a mean pressure of approximately 50,000 lbs. per square inch.

The accuracy of this armor-piercing ammunition is slightly better than that of the Model 1906 Service ammunition, and at a range of five hundred yards, about ninety per cent of the bullets cleanly penetrate hard armor plate one-fourth inch thick.

Fig. 1. The United States Rifle, Caliber .30, Model of 1903, the stock of which can be greatly improved

Stocks for the Infantry Rifle

By

TOWNSEND WHELEN

IT goes without saying that Ordnance officers should be thoroughly familiar with every detail of the design of weapons. When we design or develop a new weapon for presentation to the using service for test it should be as perfect and as efficient in every detail as it is possible to make it. We are naturally looked upon as the experts on weapons. We can only gain expertness by study, experiment, and experience, the latter including actual use of the weapon in question. Today we are endeavoring to develop a new infantry rifle—a self-loading rifle perhaps. It may not come in the near future, but when it does come it is up to us to see that it is as near perfect as careful and hard specilization can make it before we put it out.

It is the purpose of this paper to call attention to just one item in the design of the infantry rifle, but a rather important item as will be shown—the stock. Few of us who have not specialized on it have thought much about the stock. Still fewer are really competent to express an opinion on it because to understand stock design one must have had experience—much experience in actual use—shooting under all conditions with stocks good and bad, with regular service stocks and stocks made to fit perfectly. It is also necessary to observe other men, men of all types and sizes, while they use such stocks, and to be able to give correct weight to their opinions. For example, the opinion of a man who has used but one type and dimension of stock, no matter how proficient he has become with it, is of little value, because it is the opinion of only one man with very narrow experience. Also an Ordnance officer who studies the subject only in an office is apt to come to a wrong conclusion because he has had no experience which will enable him to correctly separate the sheep from the goats.

Let us first consider the stock for the present service rifle, the U. S. Rifle, caliber .30, Model of 1903, as shown in Fig. 1. The stock on this rifle is purely the product of the Ordnance Department because it was designed by it, and while the rifle as a whole was referred to the using service before adoption, yet no change in stock was made from the original model. I happen to know this personally because, while a young infantry officer, one of these rifles (No. J8½T) was referred to me for test, but at that time I was hardly competent to pass on minute details of design and construction. This stock on the Model 1903 rifle has the following dimensions:

Length from trigger to middle of butt-plate	12¾ inches
Drop from line of battle sight to comb	2½ inches
Drop from line of battle sight to heel	3¼ inches

Fig. 3 shows how measurements of stocks are taken. The old Krag rifle had a stock with dimensions similar to those of the Model 1903 rifle, except that the stock was ½-inch longer from trigger to the middle of butt-plate. When the Model 1903 rifle was first issued I was serving in command of an infantry company. The men at once began to complain that the stock of the new rifle was too short, that it cramped them too much, and that they could not hold as steadily as with their old Krag rifles. One still hears this complaint among all old soldiers who have used the Krag. Several years later an era of extreme specilization in the rifle set in, and many men began to have stocks made to order to their own dimensions. I was among this number, and we soon found that the Model 1903 stock was deficient in more respects than the matter of length, and we also discovered that the advantages of a properly designed and fitting stock were much more than supposed. Briefly, such a stock has the following advantages:

It permits of a much steadier position being assumed by the marksman, which means better accuracy of fire.

It permits the stock being held harder and closer to the person, thus minimizing the effect of recoil, and extending accuracy of fire to a greater number of rounds.

It facilitates rapidity of aim by leading the eye quickly and accurately into the line of aim.

It should be understood that in the United States Army we have developed a system of rifle marksmanship which has enabled us to get really remarkable results so that today we lead the world in this respect. This system has largely been built up around certain standard firing positions. In these positions the soldier soon finds that he is able to hold the rifle with almost absolute steadiness, that in them he has the maximum control of the trigger, and that the position and the gunsling greatly minimize the effect of the recoil. It is safe to say that without these positions we would be at the best only on a par with other nations. Each of these positions has been so carefully standardized that to depart from it in the least means a decrease in the efficacy of fire. For example, take the prone position as taught throughout our service. The position is so thoroughly standardized that if a number of photographs were taken of trained soldiers in this position they could not be told one from another, except by the men's faces. To depart from this position in one iota means loss in efficiency, and the stock should be such as will further the position in every way possible. Take Fig. 2 which shows an

old design of rifle. This stock cannot possibly be used in the standard prone position. The receiver, extending to the rear, forces the marksman to hold his head way back, places a strain on the muscles of the back of the neck, interferes with the acuteness of vision, and causes the head to tremble so that the eye cannot possibly be held steadily in the line of aim for any appreciable time. It is just such errors as this that we should avoid in the design of stock for our new rifle.

In the course of my work I come in intimate contact with a great many riflemen annually. I have always made it a point to get these men to try the rifle stocks which I have had made to special dimensions and shape. Almost invariably these stocks have been a revelation to them. They are able to do work which they were never able to perform with the regular issue type of stock. The improvement will not always be apparent in shooting one score, but it always shows an increase in the average accuracy, a great increase in the accuracy of quick fire, and a still greater increase in the accuracy of sustained fire. The man can fire a great many more shots without becoming fatigued than he can with an ill-fitting stock. These experiments with men have also clearly demonstrated that fully ninety per cent of average American men will be so perfectly fitted with a stock of the following dimensions that it does not pay to experiment further:

Length from trigger to middle of butt-plate	13¼ inches
Drop from line of battle sight to comb	1⅞ inches
Drop from line of battle sight to heel	3 inches
From center of trigger to front of pistol grip cap	3⅜ inches

Fig. 3 shows this stock in outline. With regard to the pistol grip, experience has shown that this is a most valuable adjunct if properly placed and shaped. In all standard positions the right hand does most of the work of holding the rifle up and hard against the shoulder, leaving the left hand to direct and steady the piece. The pistol grip permits the right hand to perform these functions much better and easier, and at the same time it permits much better freedom of the trigger finger and allows it to exercise much better control of the trigger squeeze. It also gives better control of the weapon in bayonet combat.

During the past year the Ordnance Department has been making special .22 caliber gallery practice rifles for the National Board for the Promotion of Rifle Practice. These rifles are made with a specially designed pistol grip stock somewhat similar to the ideal stock which I have outlined above. Fig. 4 shows a modification of this stock applied to the Model 1903 rifle. This stock has the following dimensions:

Fig. 2. A serious mistake in stock design. The Soldier cannot hold a rifle with such a stock steadily, and he will be in constant dread of the recoil. The receiver projects so far to the rear that the head must be held in an uncomfortable and strained position, and the eye is endangered during recoil of the piece

Length from trigger to middle of butt-plate	13½ inches
Drop from line of sight to comb	1⅞ inches
Drop from line of sight to heel	2¼ inches
From center of trigger to front of pistol grip cap	3⅜ inches

The stock was purposely made longer than ordinary so that the owner of the rifle could remove the butt-plate, cut down the stock to the exact length he wished, and replace the butt-plate. This stock has met with a very excellent

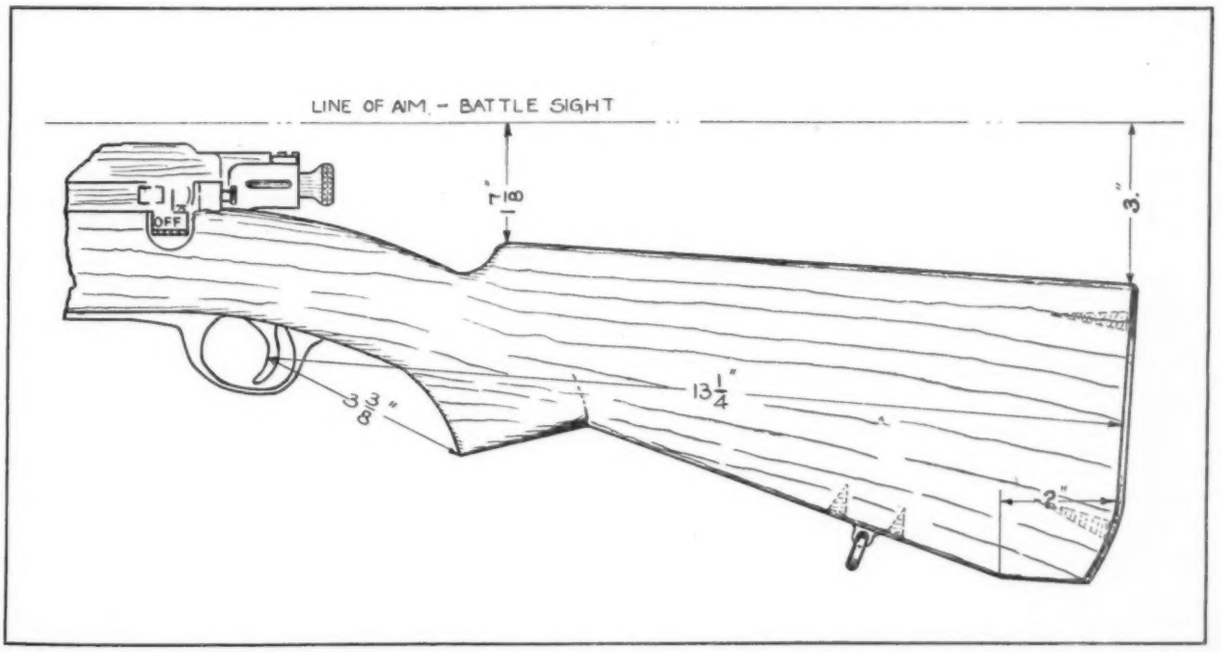


Fig. 3. The Ideal stock for the Infantry Rifle. Correct in all dimensions and contours, and susceptible of being shortened for short-armed soldiers

reception on the part of all experienced riflemen who have used it with one exception. Almost all complain that it has not enough drop at the heel. It happens that in determining the drop at the heel for this stock the advice of a very celebrated international rifleman was taken. This man shoots in a very abnormal position, and for this position he requires a very straight stock. It was simply another case of taking one man's opinion as against a hundred others. If the drop of this stock at the heel be increased to 3 inches it becomes practically the ideal stock as shown in Fig. 3.

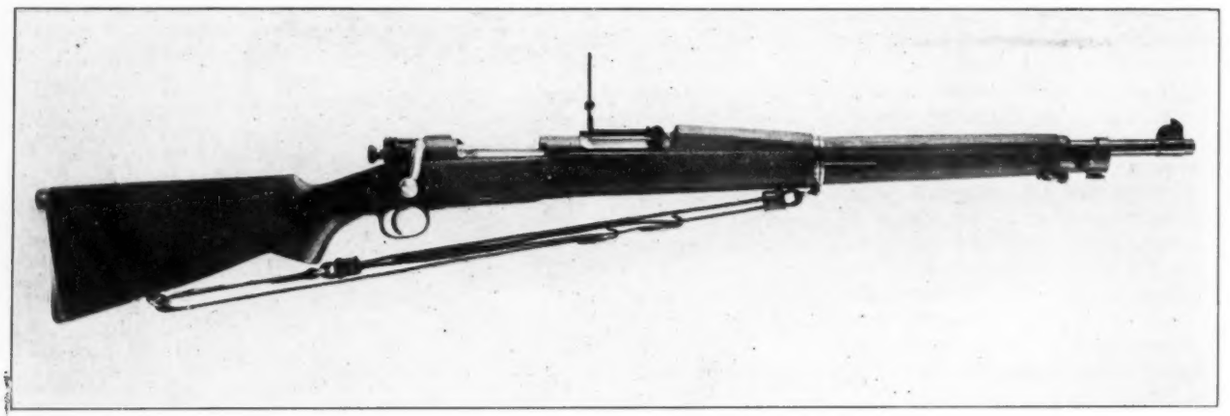


Fig. 4. The Model 1922 special stock for Model 1903 rifle. Identical in rear of the trigger guard with the stock for the Gallery Practice Rifle, Caliber .22, Model of 1922. A good design but not enough drop at the heel

In every rifle organization there are to be found two or three soldiers, short of stature, with proportionately broad shoulders and short arms. These men simply cannot handle a rifle with a long stock. Indeed they have great trouble in handling the Model 1903 rifle with its short stock. Not only is it difficult for these men to assume a steady position in slow fire, but in rapid fire it is practically impossible for them to reach the bolt handle and to function the rifle without taking the butt of the piece from the shoulder. Such men, who in numbers never exceed 3 to 4 per cent of the command, require a very short stock, sometimes as short as 12 inches, to enable them to develop efficiency in marksmanship. The ideal stock shown in Fig. 3 has been designed with these men in view. The upper and lower surfaces of the stock have been made parallel for about 2 inches in front of the butt-plate. The present roughly checked butt-plate, which is satisfactory in every respect, has been slightly altered so as to omit the curve and extension which extends over the heel of the stock, and the plate is secured to the stock by two screws entering from its face. With such a stock it will be easy for the company mechanic to saw off the butt to the required length for a short armed man, and replace the butt-plate. Authority should be given to make this alteration when the company commander decides that it is absolutely necessary. At the most not more than five stocks in any one organization need be altered in this manner, and they can be retained in the organization and interchanged on rifles as the necessity arises.

Powder Development at Picatinny Arsenal

Probably the most important development work of interest to the general public or to the Service now being carried on at Picatinny Arsenal is that of producing a smokeless, flashless, non-hygroscopic powder.

Immediately after the signing of the Armistice, demands were made on the Ordnance Department for a new type of propellant powder based on conditions found during the four-year period of the War. The particular objection to the present service powder is that it is hygroscopic and must be kept in waterproof containers up to the time of using. Another very important factor is that it is a solvent powder, requiring considerable time for drying, even making use of the so-called water drying process developed during the war.

In September, 1919, the first experimental work was undertaken. A series of experimental powders were manufactured and tested with varying degrees of success. These powders were of varying composition and granulation. In order to minimize the cost of development work as well as to produce results at as early a date as possible, energies were concentrated on two calibers, the 4-inch Stokes Trench Mortar and the 75 mm. Field Gun, and satisfactory powders have been produced and tested by the Service. In order to obtain the necessary ballistic properties and to avoid the use of solvent, nitroglycerine was resorted to, in very small amounts.

The 4-inch Trench Mortar powder as developed is a thin perforated disc which requires no bag or container to prepare it for firing. The 75 mm. is in the form of thin strips, making it very easy to handle and load. The powder is made by incorporating the various ingredients in a heated mixer and rolling the same into sheets, its plastic qualities permitting it to be cut to any desired width or length. The grains as formed retain their shape since they are not subject to the deformation which is true of most nitrocellulose solvent powders.

While the powder can be fired within forty-eight hours from the time of mixing, more uniform ballistics are obtained by allowing it to age for from two to three days. The powder is non-hygroscopic and even complete submersion of samples in water for twenty-four hours does not affect the ballistic qualities even when the powder is removed from the water and immediately fired from the gun.

Sufficient 75 mm. powder was manufactured during 1922 and loaded into complete rounds for service test at Fort Sill and Fort Bragg. The Field Artillery Board report the tests of this ammunition have been very satisfactory, only one flash having been reported. While the powder is not smokeless it produces no more smoke than the present service powder and to that extent is an improvement.

Every effort is being made to complete the development of a satisfactory "FNH" powder for the 155 mm. Howitzer. Very good results have been obtained with experimental samples to date and it is expected that a test of three samples will be made at the Aberdeen Proving Ground on or about May 1. Should these tests confirm the results obtained at the Arsenal a sufficient quantity will be manufactured to furnish the service with charges for test at Fort Sill and Fort Bragg as were carried out on the 75 mm. last year.

The Garand Autoloading Rifle

By

R. C. COUPLAND

IN designing an autoloading rifle for military use, the requirements are rather rigid. Simplicity of design is highly desired so that the gun can be quickly assembled or disassembled without the aid of special tools. All parts should operate with accuracy and precision so that failures may not occur through misfires, failures to eject, rupture of cartridge cases, etc. The bolt must be positively locked when in the forward position and be held open when the last cartridge has been fired, that the parts may return to firing position without firing, even though the trigger has not been released; that the parts in the cocked position may be safely locked against firing, and that the working mechanism and magazine be so inclosed as to prevent the entry of sand and other foreign matter which might interfere with the proper functioning of the magazine and parts. The weight and length of the gun should not be excessive, but should conform closely to adopted shoulder rifles now in use in the Army. The gun should be well balanced, handy, etc., following out and embodying general characteristics of any high-grade modern military rifle.

John C. Garand

A description of the Garand Autoloading Rifle will show how closely the inventor has met these requirements. The stock is made of black walnut, the forward end of which telescopes into the tubular rear end of receiver and is firmly secured. The trigger guard and magazine are formed as an integral part of the receiver. The upper rear end of the receiver is open for the insertion of the bolt. This opening is ordinarily closed by a cover which slides in recesses in the receiver and is held in position by a hand latch. The rear sight is mounted on this cover. The bolt reciprocates on tracks or guides formed on side walls of the receiver. The receiver is cut away on top just above the magazine for clip loading and for the ejection of empty shells. The bolt contains the actuator, recoil spring, and firing mechanism. The barrel is screwed into the front end of the receiver and is covered by the upper and lower wooden hand guards. These hand guards are held in position by a rear stock screw and the upper and lower bands. The upper and lower bands are identical with Model 1903 Springfield. The front sight is mounted on the front end of the barrel.

The action of this gun is a primer set-back type, the primer acting under the high pressures developed in the chamber sets back slightly, operating against the actuator. The actuator is thus driven back against the action of the striker spring and the energy of recoil imparted to it unlocks the bolt and carries it rearward. The energy imparted to the bolt is more than sufficient for extraction and compression of the recoil spring. The residual energy is absorbed by the buffer. In the retracting action the energy stored in the retracting spring is imparted to the bolt, the bolt moving forward feeds a new round into the chamber and leaves the striker in the cocked position. When the trigger is pulled the actuator moves forward under the action of the striker spring, driving the firing pin forward against the primer. In the present Garand rifle it will be difficult to determine the exact section of the pressure curve on which the primer is working, but it is pertinent to point out here a mechanical feature which materially assists in delaying the actuator, so that the working section is carried to a higher point on the pressure curve. When the cartridge is primed the actuator is moving forward with a rapidly decelerating motion, so that it is necessary for the primer action to overcome this forward movement and reverse its action. The slight delay thus caused allows the operating pressures to build up to a higher point than would be obtained were the firing elements at rest.

The time of unlocking of the bolt and the energy transmitted to it by the actuator depend on the pressure developed in the chamber and the average pressure exerted by the primer during its movement. From this it is apparent that a heavier bullet will only affect the action when it affects the chamber pressure curve. Overcharges build up the chamber pressures to a higher point and increase the energy of recoil and the speed of operation, but at the same time the velocity of the bullet is increased, compensating to some extent the decreased time of unlocking. Under charges will reduce the energy imparted to recoil and, as was shown in the test on this rifle, reduced charges of 25 per cent failed to function the mechanism. The inventor has allowed for the absorption of a certain amount of surplus energy by the buffer for normal pressures; when pres-

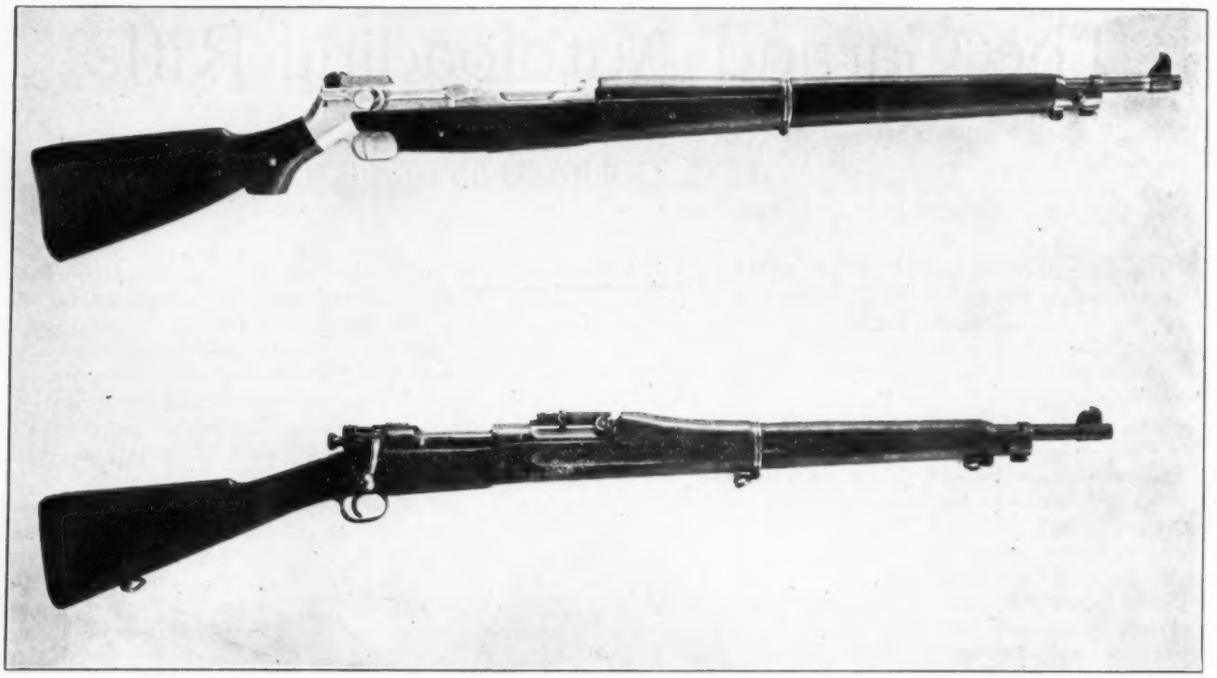


Fig. 1. Comparison of Garand Autoloading Rifle with Springfield, Model 1903. Both Rifles have 24-inch Barrel

sures are reduced below minimum, failure to function results.

The closing action and firing mechanism are independent; it is, therefore, mechanically impossible to fire the gun when the bolt is in an unlocked position, and the bolt cannot unlock until the actuator has traveled about .75 inch against the action of the striker. The manually operated safety locks the sear pawl, holding the sear lock and sear inoperative and making it impossible to fire the gun by the trigger.

The type of lock is very similar to the Hotchkiss. This style of offset locking surface has proven satisfactory in several types of weapons. The locking seat is a separate unit seated in the receiver. This is considered a good feature. It permits of special treatment in the locking seat, and greater bearing area on the receiver, and is easily renewed. There is no rotation to the bolt and extraction is straight to the rear. Primary extraction is facilitated by the camming action of the actuator on the unlocking lug, forcing it down and thus exerting a considerable leverage on the locking lugs operating on a shoulder in the receiver and forcing the bolt to the rear for a short distance.

The sear mechanism is placed in the lower part of the receiver and consists of three principal parts, the sear pawl, sear lock and sear. The moving parts of this gun are well housed in the receiver, offering maximum protection to the firer. The integral construction of the magazine and receiver allowed cutting away of both sides of the receiver above the magazine, making it very well adapted to clip loading. The gun is easily dismounted for cleaning the major parts. The upper rear end of the receiver can be quickly removed by releasing a catch with the fingers. The bolt, actuator and springs can then be easily withdrawn in a unit for further disassembly and cleaning. The barrel can then be cleaned either from the muzzle or breech. The

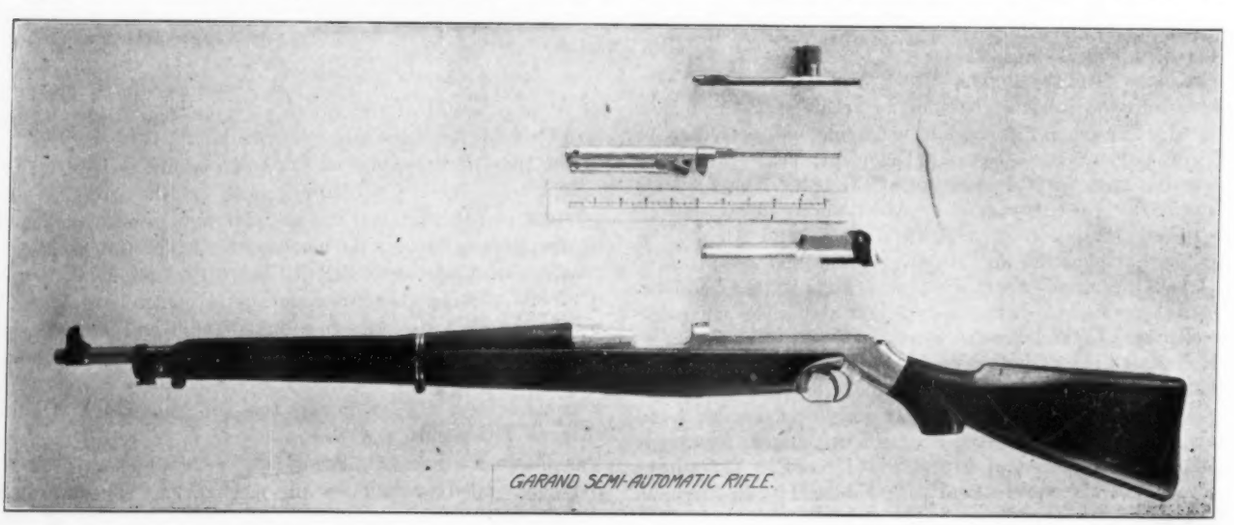


Fig. 2. Disassembly of the Principal Parts of the Garand Rifle

gun is adaptable for the carbine type of weapon by shortening the barrel. This would not interfere with functioning, but it is not considered advisable to use the present service ammunition with a shorter barrel.

Some difference of opinion has existed about the Garand gun relative to the position of the bullet when the bolt unlocked. The chief concern about this was whether or not the bullet had left the muzzle before unlocking took place. Assuming an average primer pressure of 25,000 pounds, we calculated that the actuator had traveled about .25 inch before the bullet left the muzzle, and the average speed of the actuator to be about 17.25 foot-seconds. The actuator must travel .75 inch before the bolt unlocks. This then places the bullet about 7 feet beyond the muzzle before unlocking takes place. Now, assuming an average primer pressure of 50,000 pounds (i. e., equal to the maximum chamber pressure), the average velocity of the actuator is about 27.1 foot-seconds and the actuator travels about .36 inch before the bullet leaves the muzzle, and the bullet is about 3.5 feet beyond the muzzle when the bolt unlocks. To verify the above calculations, tests were conducted at Springfield Armory on the rifle with a Boulengé chronograph. The bullet cutting the circuit of the recording magnetic coil at the muzzle and the unlocking of the bolt broke the circuit of the registering magnetic coil. When both coils were cut simultaneously a zero point was obtained and it can be readily seen that if the bolt unlocked before the bullet left the muzzle, an indicating point would be obtained below the zero point, while if the bullet left the muzzle before unlocking took place the indicating point would be about the zero point. Twenty shots were fired with the 150-grain bullet. The indicated point was above zero, with an average time difference of .004615 second, which, assuming a muzzle velocity of 2,700 foot-seconds, places the bullet about 12 feet beyond the muzzle when the bolt unlocks. Twenty shots were then fired with the 170-grain bullet. The average time difference was .003431 second; using the same assumptions as before, places the bullet about 9 feet beyond the muzzle when the bolt unlocks. To check the chronograph, the muzzle screen was moved away until the two coils were cut simultaneously. This occurred when the screen was about 8 feet beyond the muzzle.

The energy of recoil of the Garand gun is less than it would be without the autoloading features by an amount which closely approximates that absorbed by the primer action, which is about 20 per cent. The accompanying chart shows a comparison of the recoil energy of five guns of varying weights, taken on the recoil machine at Springfield Armory. The initial pressure on the recoil machine is 25 pounds, and the weight of the reciprocating parts is 5.062 pounds. Then tabulating the theoretical energy of recoil with the recorded energy for each gun we have:

Rifle	Theoretical recoil energy foot-lbs.	Recorded recoil energy foot-lbs.	Difference recoil energy foot-lbs.	Weight of gun, in lbs.
Springfield	5.17	5.50	plus .33	8.628
Sporting Springfield	4.93	5.33	plus .40	9.410
Garand	4.75	4.50	minus .25	9.813
Model 1917	4.76	5.40	plus .36	10.000
Heavy Springfield	4.37	4.69	plus .32	11.08

(The weight of the reciprocating parts of the machine has been taken into consideration in the above calculations for theoretical recoil energy.)

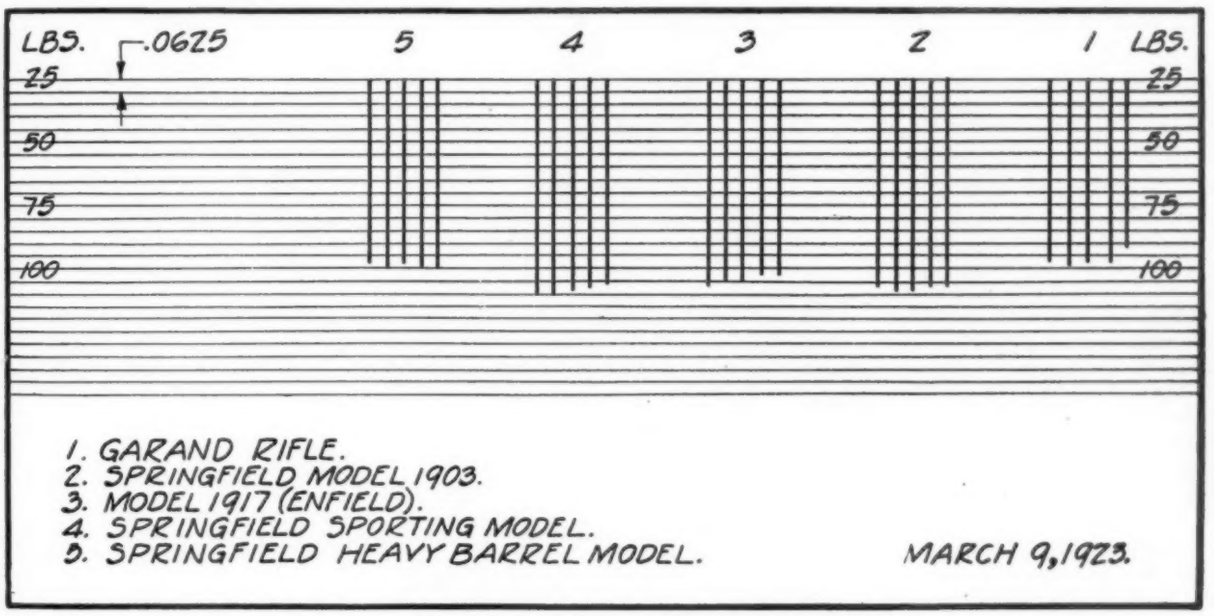


Fig. 3. Chart showing Recoil of Various Rifles

It is seen from the table that the Garand gun has a recorded recoil energy much below the average of the other guns, with the recorded recoil energy .25 less than the theoretical value, while the average recorded recoil energy of the other guns is about .352 greater than the theoretical recoil energy, which shows that the approximate loss of recoil energy in the Garand gun due to the autoloading features is about .702 foot-pound, or about 16 per cent. The energy returned to the gun through the buffer by the moving element is approximately 20 per cent minus 16 per cent, or 4 per cent.

No accuracy tests have been conducted with the Garand gun. It has a fixed barrel and the accuracy should be good. The gun is well proportioned, easy to handle, has a good balance, and is a fitting monument to the work of a master craftsman. The design and construction of the Garand Rifle is a noteworthy contribution to the development of small arms.

International Rifle Shooting and the Free Rifle

By

L. W. T. WALLER, Jr., U. S. M. C.

THIS year the International Matches, held under the auspices of the International Shooting Union, will be held in the United States at Camp Perry, Ohio, during our own National Matches there. The time of holding these events will be between September 2 and 27, 1923. The National Rifle Association is affiliated with the International Shooting Union and will act as the sponsor of the matches.

International Matches are held every year by the International Shooting Union, and in the countries of the various nations affiliated. We have had them before, in 1913, and since that time the interest in the "free rifle game" has picked up considerably. We have sent three teams abroad in recent years to participate in this class of matches, the last two teams having been successful in winning, in 1921 at Lyons, France, and in defending, in 1922 at Milan, Italy, the much-desired Argentine trophy, the cup emblematic of the World's Championship in this type of shooting. This trophy was presented to the Union by the Argentinos about seventeen years ago, and except for our two wins has been held by the Swiss ever since its presentation.

The United States also holds the International Long Range Trophy, the Palma Trophy. Under the present rules of the match, this must be shot for with the military arm of the competing nations; and as other nations consider our Springfield the best military rifle in existence, it is unlikely that they will compete. As Great Britain and her colonies are about the only ones who shoot long range, apart from ourselves, the Palma will never attract as many competitors as the free rifle matches.

Courtesy of Arms and the Man

The Palma Trophy

The advantages of being a regular contestant in International Rifle and Pistol Matches are rather obvious. It gives us a broader viewpoint and a more general understanding of shooting conditions the world over. To rub shoulders with the rifle "cranks" of all nations is a liberal education in itself. They have many ideas in which we would never concur, but at least it does us no harm to know what these are. They also have many ideas it would pay us to study and apply to our own use. Other reasons why we should participate in International Matches could be advanced, but that seems hardly desirable. It can be assumed that such participation is advantageous. Starting with this assumption and looking the field over, it would appear that the Free Rifle Matches of the International Shooting Union offer the best means to this end. We can shoot the Palma whenever it is possible; we can shoot the free rifle every year, and while this is not the American type of shooting and should never supplant our open range shooting, approximating service conditions, still it is an old established shooting sport; one in which we can rub shoulders with the world, and, finally, one in which we have been successful, and, therefore, in which we must continue to put the best we have.

I think it will be agreed that we should continue to do the best we can. In 1921 we won both the Team Match and the Individual Championship, while in 1922 this was repeated, Mr. Stokes, of Washington, D. C., successfully defending his individual championship, winning the championship of the kneeling position and tying for the championship in the prone position, but being outranked. Commander Osburn, of the Navy, tied for the championship standing, and was outranked. With this fast pace set as an example to follow, to continue to do the best we can narrows itself down to winning all events. For the benefit of those who have not followed the Free Rifle Matches, a brief description of them is given.

All shooting is done at 300 metres on a decimal ring target, in which the ten ring is approximately four inches in diameter and all counts down to the four are in the black. The match consists of firing 120 shots, forty in each of three positions, standing, kneeling, and prone. Ten sighting shots are allowed which may be taken at any time on a target for that purpose only. The match must be completed in one day, but apart from this there

are no time restrictions. Teams consist of five firing members; coaching is allowed. The Individual Championship of the World, and the Individual World's Championship in each of the positions are decided by taking the highest aggregate of the individual team members in the team match. No separate match is shot for these. Shooting is done from a house or shelter, the kneeling and prone positions being generally shot from a bench. As these benches are usually pointed straight down the range, and are very narrow, they seriously hamper us in prone firing by preventing our firing on an angle to the target, as is the custom on our ranges. The matches are shot with the "free rifle" which means literally what it says. No glass is allowed in the sights, but apart from that there is no restriction—any calibre, length of barrel, weight, stocking, etc., are permissible. Range rules vary in the different countries, and are in many respects different from ours. Last year it became necessary to throw a member of the Swiss team out of our booth while the shooting was going on because he was protecting the position of one of our shooters. Instead of making his protest to a range officer, he came in talking at the top of his voice, and was about to grab our shooter while he was firing when he was bodily seized and ejected.

In European countries, Switzerland particularly, rifle shooting creates more interest than it does in this country. In Switzerland it is the national sport, and the best shots are known in much the same way as our best baseball players are. One of our team members visited Switzerland after the match and was continually spoken to by hotel managers, porters, cab drivers, etc., all of whom knew the results of the matches, scores, why the Swiss had lost, and all of whom took a great interest in everything pertaining to shooting.

On the other hand, apart from the comparatively few "shooting cranks" in this country, hardly anyone knew there had been a match. In the tryouts for the American team, held at Quantico, Virginia, thirty men appeared, and of these seven were taken abroad. At Milan the Swiss had about two hundred shooters, and while they were very close to home, it is true, they actually brought more men to the matches than we had in our tryouts. Who knows how many men tried out for their squad! We would have had more men to try out except for the expense involved. To try to obviate that, this year it is intended to hold regional tryouts under the Corps Area Commanders, and to hold a final tryout at Camp Perry. This should get the best material in the country, and it is pleasing to note that more interest is being shown daily in these tryouts and in the International Matches.

Because of increased interest by the shooters, and the proposed tryout system, I believe we will have the best team this year we have ever had. This does not mean we will certainly win the match. The Swiss, our principal opponents, are smarting under two consecutive defeats and will leave no stone unturned to stage a comeback, and it is to be noted that neither of our winning teams have topped their high record. Last year they were shooting much better in practice than they did in the match, while the reverse was true of our team. We had had a long hard trip, during which we had been subjected to many annoyances which culminated in having our ammunition taken away from us, which, however, was recovered prior to the match.

Our two wins are due to one thing alone, our ability to use the sling in the prone position. Both years we have won we were badly beaten in the standing and kneeling positions, but were able to offset this prone. We have taught the European countries how to use the sling, so in time they should be able to shoot prone as well as we do; therefore it is up to us to equal them standing and kneeling. And I might add that we are improving in these positions—I hope as fast as our opponents are improving prone.

The Argentine Trophy

Courtesy of Arms and The Man.

One of our serious handicaps in the free rifle game is the lack of a suitable arm. Abroad nearly everyone who shoots at rifle matches has a free rifle of some description. As our shooting is largely done with the military rifle, we have no suitable free rifle. Even the small bore rifles are patterned after their larger military brothers, and the old Scheutzen rifles and Scheutzen clubs are almost a thing of the past. Abroad the Martini is generally used—being a lever action its lock time is faster than our Springfield. These guns are fitted with peep sights well back to give the maximum sight radius. They are long barreled and heavy, with palm rests, double set triggers, and deeply curved butt plate, which permits the butt to nestle into the shoulder offhand. I am inclined to believe, however, that many of these butt plates are so made that they do not give the best results prone. The trigger guards are large and made up of curves and grooves, so that the fingers fit into them, always resting in the same place. The rifling of one of these guns is given as a matter of interest, and it may be said that many of our shooters do not believe our present twist is productive of the best results for 300 metres. This rifle has a groove diameter of .311, and the pitch is one turn in slightly over twelve inches.

Last year we took the Springfield with a pressure barrel as the base of our free rifle, stocking it with what might be called a modified sporting stock, long, fairly straight, and with a broad beaver-tail fore end. A palm rest adjustable for length and fore and aft movement was designed and added. An "L" shaped butt hook was fitted to a special butt plate, having the effect of a pronged butt plate and being adjustable for length; the vertical shank of the "L" fitting into a groove in the butt place. This was used for standing and kneeling, and removed for prone shooting. Such an arrangement is very essential, as the free rifle is muzzle heavy and needs some steadying arrangement at the butt. An adjustable front sling swivel was added, the sling swivel itself sliding in a dove-tailed groove in the fore end. Double set triggers were added and the lock time speeded up as much as possible. This was accomplished by cutting off the cocking comb, reducing the travel of the firing pin, milling the pin itself to make it lighter and increasing

the length of the spring to get the necessary force. The rear sight used was the standard Lyman 48, but very large disks, 1¼ inches in diameter, were fitted, the peep hole in these being smaller than in the standard disk. For a front sight, a hooded sight cover was permanently fitted, forming a cover and front sight mass. Into this various types of sights could be used, such as the aperture, past, etc.

The specifications for this year's rifle are essentially the same as those for last year, with the important exception of length of barrel, which will be thirty inches instead of twenty-four.

The question of a suitable free rifle is one which is arousing much interest, and more and more of these guns are being made available. We should conduct experiments to settle many disputed questions, and to act as a basis for the development of a free rifle essentially American and within reach of the pocketbook of the average shooter. We should know, for example, the proper length of barrel, size, depth and number of grooves, the proper pitch of rifling, the proper weight and shape of bullet and powder charge to produce the best results at 300 metres. These and other questions along the same lines will doubtless in time be fully answered, in fact, I feel sure that much valuable data is now available in different places and only needs to be coordinated and carried to conclusions. The shooters rather look to Aberdeen to answer these questions, as far as the rifle is concerned, while the loading companies can give much data on bullets and loads.

The training of free rifle shooters will almost take care of itself once sufficient interest is aroused, and suitable weapons are obtainable. Already matches are proposed to closely follow the International Match rules and conditions. The essentials to good shooting at this game are the same as for all other shooting—good physical condition and practice. Constant practice is even more essential in this type of shooting than in our own kind. There is little wind doping, for example: to see properly, hold steadily, and to have the stamina to hold up under the grind of a long match are the principal factors which enter into the make-up of a successful shooter. I know of men who have a free rifle in their rooms and who, while dressing and at other times when possible, snap in for ten or fifteen minutes every day. These men are excellent shots, and they are made right in their rooms and not on the range. Range work is necessary, but is more in the nature of a demonstration of ability than of training after a shooter has mastered the elements of the game.

It is hoped that these notes will add a little to the growing interest, and help to popularize the free rifle game.

Special Features of National Match Rifles

By

S. H. MacGREGOR

IT has been contended, for a long period, that in the spring various fancies turn in various peculiar ways. The first robins arrive with a revielle call for hibernating hobbies. Enthusiastic riflemen commence to figure on the probable date of the National Matches and there is a stir of action towards collecting an array of time tables, summer resort guides and kindred publications.

Naturally enough the wise man, whose business it is to prepare time tables and resort guides, has anticipated this perennial return of hope and has prepared his wares in advance. In a similar manner the results of the past year at Camp Perry have been studied and plans laid in advance for the production of the rifles which are to comfort the hearts of those who will compete this year.

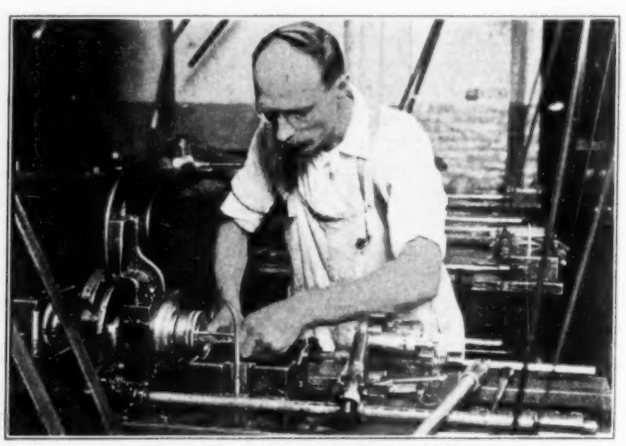


Fig. 1. Gauging a Barrel During Rifling

To those who have indulged to any extent in rifle practice it is not necessary to describe the feeling of warm satisfaction that follows watching a white disc creep up over the target after each shot. Having taken the greatest of care in his aim, having followed with even painful accuracy everything that his experience and education have taught him, it is only corroboration that the rifleman needs from the pit. A bull's-eye signal is, then, not so often an indication to him that he has just shot straight as it is an admission that he has shot when he knew he ought to shoot. What woe, when, after all this painstaking care, there is a slight delay at the pit and then a red disc appears, or perhaps a disheartening black and white cross. To some it has happened that a somewhat longer delay has preceded a red flag. Those moments of hesitancy—those tell-tale delays at the pit—are familiar items in the list of rifle-range disappointments.

And when these things happen the marksman is often prone to lay the blame on the gun. An examination of the sights, a careful scrutiny of the base and sides of the offending cartridge case often indicate that the wild shot must be laid to some unknown cause, some sudden fancy of the elements—a lapse in the wind and, sometimes, perhaps, too often, to some idiosyncracy of the rifle. Too

seldom it is the admitted fault of the rifleman.

And perhaps for the very reason that our human weakness causes us to look about for an external cause we have from time to time examined into possible causes in the rifle. Thus we have gradually worked out dimensions and characteristics which are such as to minimize errors of material. Having arrived through many experiences and many years of investigation, at ideal requirements, and having measured these against fundamental requirements pertaining to weight, balance and form of military weapons, we have arrived at the specifications for National Match rifles which represent the present authorized military arm of our service in its most accurate and refined state.

The National Match rifle is the service caliber .30, Model of 1903, manufactured under special conditions of care and workmanship. The important dimensions are as specified for the service rifle except as to tolerances which are closer. Some changes are made in the trigger mechanism and the trigger pulls are made lighter.

Accuracy will depend largely upon the barrel construction and it is with barrels that the greatest care is exercised. Specially selected stock is used and boring and reaming is held to a minimum in order that the rifling operation will not exceed limits. The last reaming produces a barrel between .2999 and .3000 inch and the rifling operation brings the dimensions to, bore .3000 to .3005, and grooves .3080 to .3085. In any barrel the variation in dimensions must not exceed .0001 inch.

When it is considered that the average hair is .003 inch in diameter it can be safely assumed that no rifler coined the expression "a hair's breadth." A discrepancy equal to the width of a hair would constitute a hopelessly irreparable defect.

In all operations on the barrel tools are specially selected to give minimum dimensions. Highly skilled tool dressers watch the results, and frequent gaugings prevent

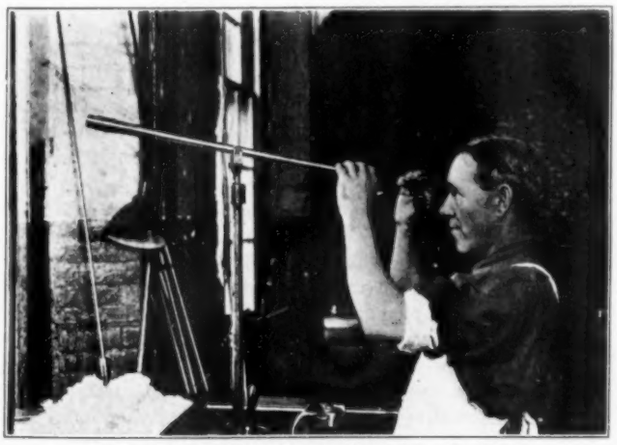


Fig. 2. A Rifle Machine Operator Examining His Work

the use of tools which have become the slightest bit defective.

In figure 1 is a rifler carefully gauging a barrel which has been in the rifling machine long enough to have approached very near to the finished dimension. This machine, equipped with a double scrape cutter, rifles a barrel in about one-half hour. So fine are the chips or scrapings that, as they are collected in the end of the machine, they resemble oil-soaked waste. The metal is in such a finely divided form and so soaked with oil that care must be taken to remove the cuttings frequently to a covered receptacle to prevent spontaneous combustion.

In figure 2 the rifler has finished the rifling and is carefully examining the bore for rough places or pockets. He is using a magnifying glass and, as he slowly rotates the barrel, every portion comes under his close scrutiny.

Between riflings, the scrape cutters are examined under a glass and carefully stoned to the proper curve and to a

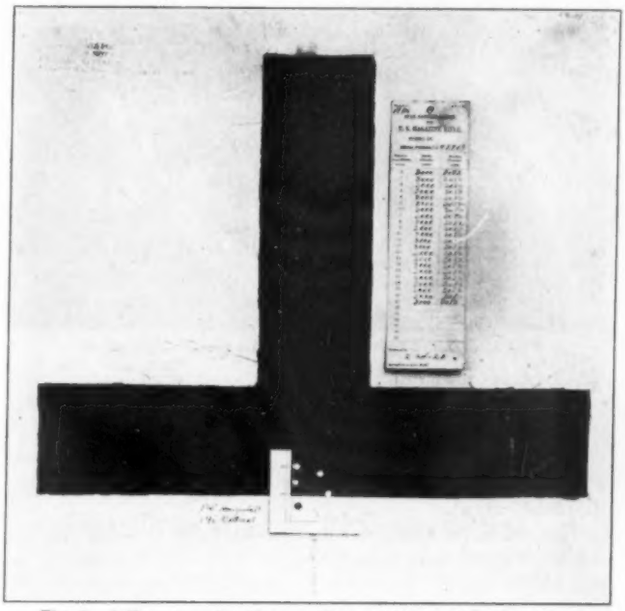


Fig. 3. A Target used to Target a National Match Rifle at 200 Yards
At right: A Sample Star Gauge Tag

keen edge. This stone is almost as smooth as a baby's cheek, yet so much care is exercised in this operation that only one or two strokes of the stone are taken before an examination of the edge is made with a magnifying glass. How many riflemen who cling to the old straight razor would take this much care with the edge of the instrument which is to scrape their faces?

The result of this careful stoning is a very smooth barrel and one that is accurate. Figure 3 shows a sample target fired at 200 yards from a muzzle rest. The dispersion is 1½ inches vertical and 1¼ inches horizontal. A sample star gauge sheet shows the diameter of lands .3000 and of the grooves .3082 without variation throughout.

Equal care is exercised in the manufacture of other components, and special operations are included in polishing sliding surfaces of the bolt and receiver mechanisms. The nose of the sear is made .0075 inch shorter than as made for the service rifle and sears and triggers are not parkerized. Mainsprings are carefully selected and gauged to insure that there is no friction between springs and bolts. Strikers are of minimum length and projections are held between .058 and .063 inch. These requirements insure better trigger pulls and smooth operation of bolts. Bolt lifts must not exceed 15 pounds and trigger pulls must be between 3½ and 4½ pounds.

Chambers are as near minimum as possible and headspace must be from 1.940 to under 1.944. A headspace of 1.944 is cause for rejection. This headspace requirement must be fulfilled after proof and function firing, because a slight setting of parts will cause headspace to

be greater after function firing takes place than before.

Cocking pieces are given a case-hardening that will produce a case of about .012 inch. This case is made heavier in order to allow the nose to be stoned to individual taste without getting through into the softer material. Some difficulty has been encountered in previous years because inaccurate stoning often produced a soft wearing surface and consequently an easily worn-out component. With an increased case it is expected that a greater amount of stoning will be possible without undesirable results.

Fig. 4. Testing Front and Rear Sight Base for Alignment

The receiver and barrel are carefully bedded in the stock. Upper and lower bands are loose enough to be put on by hand. The guard screw holes are bushed with a split bushing so that the guard screws when assembled securely hold the rifle and are not likely to become loose. Special instructions prohibit removing the guard screws for this reason.

In figure 4 an inspector is checking up the sight bases. His fixture holds the barrel by two plugs, one in the muzzle and one in the breech. A straightedge is brought down on the front stud and the barrel rotated to bring the surface of the stud horizontal. The surface of the fixed or rear sight base is then tested with the straightedge fixture seen at the right end for height and for distortion with reference to the front stud. This is a very delicate adjustment and insures that the sight bases are parallel and at the proper height above the line of the bore.

Fig. 5. Inspecting National Match Barrels

Figure 5 shows a corner of one of the inspection rooms where at the left an inspector is making the final inspection of the bore, and at the right star gauge readings are being taken.

Figure 6 shows how National Match rifles are targeted. Expert shots are used for this work and one man is able to shoot about 15 or 20 rifles per day. More than this number per day for a long period would produce undesirable physical strains which would tell on the quality of the work.

Having followed the specifications for National Match rifles very closely, there is produced a weapon which has a barrel as accurate as it seems possible to make it, a bolt which is polished for smooth action in a polished receiver and therefore quickly and easily operated, the minimum headspace to eliminate inaccuracies from that cause, a carefully gauged mainspring to insure quick ignition after releasing the firing pin, a smooth, fairly light trigger to eliminate pulling off the target and other less important features which in combination represent the ideas of good shots. At the same time the rifle is essentially the service rifle, the manufacture of which is being improved each year as greater ease is attained in the manufacture of National Match rifles.

Fig. 6. Targetting National Match Rifles

The marksman who uses a National Match rifle need blame his red flags on causes other than the idiosyncracies of his rifle. Each rifle is targeted in a muzzle rest by an expert marksman and when delivered at Camp Perry is to be safely assumed a specially selected weapon of extreme accuracy. Greater accuracy is not to be expected without changes in design which would immediately make the weapon a special freak rifle.

It is interesting to note that the workmen who combine to produce these rifles take so keen an interest in the work that they feel a personal responsibility in the performance of their product at the Matches. These men, many of them approaching 30 years of Armory service, are expert at their vocations. Their entire lives have been spent in working up to their present expertness and their workmanship is typical of the master craftsman. To them the failure of a rifle to make a good record is an indication of failure on their part and for this reason they jealously guard their work against any possibility of inaccurate or incomplete inspection.

With a spirit like this it is safe to assume that National Match rifles will improve each year.

Small Packages from an Engineering Standpoint

By

ROWLAND W. PINGER

THERE are but few lines of human endeavor where it is not necessary, at one stage or other, to balance the cost of introducing a new method against the saving in money, time, and patience thus involved. In fact, a noted man once expressed the opinion that "An engineer is a man who can do for a dollar what any fool can do for two." This definition would justify the writer in stating that there is no place in industry where an engineer can do more good than in studying and eliminating the causes of

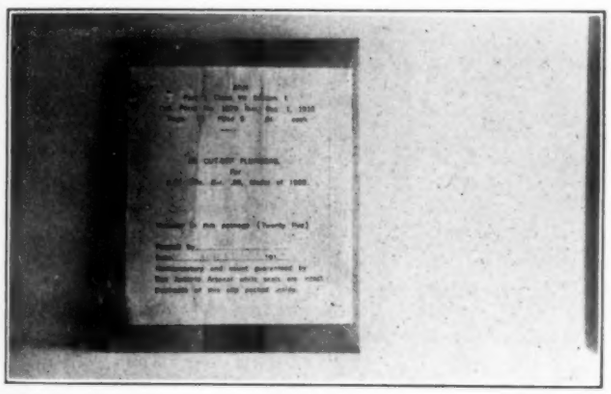


Fig. 1

waste. Likewise, an ordnance officer need not feel that the technical or manufacturing sides of the Ordnance Department are the only ones where true engineering ability may be displayed. Waste occurs almost everywhere. Sometimes its existence is temporarily cheaper than a method for its removal; in most cases, however, it is worth studying and evaluating.

In the spring of 1916 a little arsenal in Texas was blissfully pursuing the even tenor of its way when a national emergency threw upon it a very heavy responsibility. From having to supply the meager wants of a few thousand regular troops within its supply area, it was called upon to furnish ordnance matériel to a force comprising practically the entire Regular Army and National Guard then existing in the United States. Some of the former were units only recently authorized under the first national defense act. Most of the latter were only about fifty per cent equipped, local newspapers to the contrary notwithstanding. There were many untrained men in both forces, causing relatively large issues to cover breakages and losses.

The utmost efforts were made to meet the contingency. New storehouses were built, shelving installed, personnel doubled and redoubled. Freight moved out in quantities never before dreamed of, and mail came back in great volumes, and therein lies my tale.

At least two-thirds of this mail consisted of letters painfully pounded out by little outfits scattered all up and down the border, and the gist of them was:

(a) When am I going to get my rear sight drift slide screw pins? I put in my requisition by wire three weeks ago and haven't heard anything since.

(b) My rear sight drift slide screw pins arrived yesterday at last; however, you invoice 160 and I find only 158, although my sergeant and I have washed the cosmic off and counted them five times. Also the other fifty-six items are short from one to five articles each as per attached list. Please make up the shortage and spare me the agony of a survey; we have other things to do down here.

It was not difficult to locate the cause of the trouble. Inquiry developed the fact that the head storekeeper had gone home with nervous prostration induced by a conscientious attempt to check each outgoing shipment personally. His place had been taken by his bright, young understudy, who immediately realized that he couldn't physically follow his chief's example, and had to delegate the work to imperfectly trained assistants. It was also noticed that practically all complaints referred to small articles, such as spare parts for small arms, buckles, snaps, etc., then issued by the Ordnance Department. These were counted out by the crudest methods and laid out in groups of five or ten on long packing tables. A single invoice for a "six months' allowance" for a small organization would frequently cover two such tables, each 3 by 30 feet long. Not only was the counting a most laborious procedure, but the identification was usually possible by but a few men long employed. To use common labor, especially negroes, was absolutely impossible, except for the simplest part of the proceeding. Even where so used, the final check had to be

Fig. 2

made by a man capable of executing an affidavit in case of reported shortage. Thus many a time laborers were idle, tables full, and work at a standstill awaiting the action of an overworked checker.

The cause being so apparent, the method of its elimination should have appeared equally obvious but, strange to say, it was weeks before a practicable solution was thought out. It was simply this:

"Pack small articles in such a way that any reasonably intelligent person can identify and count them with the least possibility of error and in the least possible time. Also pack them in such a way that these characteristics are preserved so far as practicable right down to the point of use."

Practically, this meant packing small articles in substantial envelopes or cartons, each preferably containing ten or a multiple thereof. If in envelopes, ten of latter would then be packed in a carton forming what was called a "secondary" package. Figure 1 shows a "primary" package containing twenty-five "slide-stop plungers" as packed by San Antonio Arsenal in 1917. A few of its details are believed worthy of special attention.

The articles themselves were first wrapped in thin, tough "Kraft" paper, which protected the envelope against cutting through, and against the grease with which the parts were habitually covered. A label identical with one on outside of envelope, but ungummed and blue in color, was inserted for use in reporting possible shortage or in case of obliteration of outside label. In certain climates it had been found that the usual gum on envelopes was unreliable. The packages were, therefore, sealed by the use of gummed tape, the *ends of which were brought under* the final label.

Several points with respect to the label are of importance:

(a) Symbol at top permitted quick checking of stores (besides saving of packing desk space) when arranged as in Figure 3, without the laborious reading of label on each individual package.

(b) The price of the article was useful in impressing ignorant labor with the value of ordnance material. A box containing ten envelopes "AYE" was obviously worth $7.50 and treated accordingly.

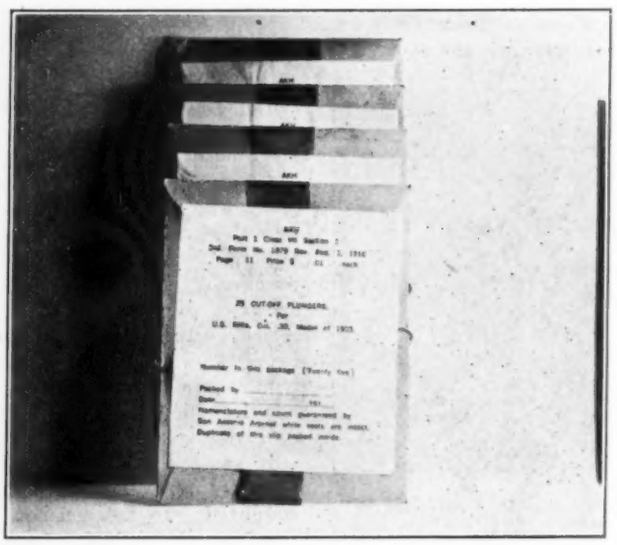


Fig. 3

(c) The name of packer was placed on each package. The sense of personal responsibility thus engendered resulted in a whole year passing without a single "internal" discrepancy being reported.

(d) The name of guaranteeing arsenal was plainly given. This encouraged keeping stores in original packages as long as possible, with consequent increase of efficiency in inventories, transfers, etc. In this connection attention is invited to Figure 2, which shows a method of packing in which this important feature (as well as others) is omitted. A skeptical ordnance sergeant of the old school will unhesitatingly open such a package, satisfactory as it might be from other standpoints.

The system above outlined proved so satisfactory on the Southern Border that it is a great pity that it was not immediately adopted upon the outbreak of the World War. It was felt that the proper place to perform the work established was at *the point of manufacture* and not at the *intermediate point of distribution.* An attempt was therefore made to interest the various manufacturing arsenals, but without success. They were quite satisfied with their existing practice and could not visualize the work and worry thrown upon the field service by such methods. This was not surprising, as a manufacturing establishment dislikes anything which *apparently* increases the cost of its product. The writer has seen canteen corks packed 10,000 to the box and accounted for by number (and not volume or weight). The manufacturing arsenal apparently was uninterested in the salary of the man at the first receiving depot, who had the job of counting up the corks and assuring his commanding officer that there were actually 10,000, and neither 9,999, or 10,001. Subsequent occasional inventories were of still less interest.

In fact, so great was the tendency to follow past precedent that the first few million spare parts for small arms ordered from civil manufacturers were ordered packed in assortments corresponding to the old "chests for 100 arms." The latter were excellent for the old Indian fighting days, or even at later dates, where a troop of cavalry was sent many miles away for indefinite periods. Each chest contained from two to five of each commonly needed article, and some, such as spare butt plates, which were almost never needed. However, as a method of supplying parts in quantity for 3,000,000 men in France, it was nothing short of ridiculous. As a matter of fact, during the border affair every one of such chests in storage at San Antonio had long ago been broken into, and the scarcest part, for the time being, removed. As they could not then be issued as complete assortments, they were finally completely unpacked and repacked as above described.

In this connection an odd thing was discovered regarding the original history of these asortments. Instead of proportioning the various components to the actual rate of consumption by troops, the following method is understood to have been used. Ten thousand rifles turned in by troops were "cleaned and repaired" and record made of the new parts required. Dividing these quantities by 100 gave the desired figures. This method failed to take into consideration the fact that troops, before turning in a rifle, invariably strip it of any expendible part for which they have any use. For example, when so much difficulty was experienced with broken "strikers" in 1915-1916, practically no rifle turned in to San Antonio Arsenal had a serviceable striker. According to the above hypothesis, a chest should have contained 100 strikers, but the arsenals compromised on 30. However, neither figure had any true basis; if strikers are defective 100 arms may need 1,000 each six months in order to keep them in condition to shoot.

To go on with the story, it was realized that for use in the camps at home and abroad, the only logical method of packing of small-arms parts was that which had been worked out at San Antonio. This method would obviously permit the employment of female labor at the factories in the United States, thereby eliminating as far as practicable enlisted labor in the field. The increased bulk was of no particular consideration compared with that of other commodities and especially with that of the food and clothing of the soldier packer whose labor would otherwise have been required.

An officer was sent to the Eddystone plant of the Rem-

ington Company and directed to work out a complete scheme for packing parts for the U. S. Rifle, model of 1917. Every detail, even to the size of wrapping paper was investigated and recorded. Two standard envelopes, one double the size of the other, and eight or nine standard cartons were developed. These were so designed that the exterior dimensions were as nearly as practicable multiples of two inches, permitting use of uniform wooden packing cases and shelving.

Existing contracts were then modified and practically no difficulty encountered in putting the project into effect. The "chests" already on hand were utilized after discarding the interior separators and diaphragms. Thereafter the use of a wooden packing case approximately 15 inches by 15 inches by 30 inches was prescribed to meet the desires of the transportation authorities who were attempting to standardize the dimensions of exterior packages.

Unfortunately, the first "sizeable" overseas consignment of parts thus packed was lost by the sinking of one of the few ships lost during the war. Being interested to learn how this loss was counteracted in France, the writer investigated and learned that in the absence of spare parts, complete rifles were merely disassembled and spare parts thus "manufactured." To the cost of labor involved in assembly and disassembly must therefore be added the total cost of producing and transporting the unnecessary components if a true estimate of the vast loss is to be made. If 30 strikers are needed to each butt plate, the cost of laying down 29 butt plates in France must be added to that of the 30 strikers; to this must be added the unnecessary barrels, bolts, stocks, etc., each in its proportion.

The war is now a long time over and there is a great tendency to slip back into old ways, especially if we can pinch off a penny or two here or there. Our storehouses are crowded with millions of articles, some of which can never be used without the manufacture of other components. We have, however, other millions for which a national emergency will create a tremendous demand. Are we as ready as we should be to supply it? It is doubtful.

In the meantime, our manufacturing arsenals are still producing a small quantity of small articles at a high unit cost to which the cost of proper packing would add but infinitessimally. The cost of identifying and reidentifying these articles in the average depot is out of all reason. All of this could be avoided once for all by the scheme above outlined, modified to meet special conditions. Labels could be made to include piece marks, drawing number and revision date, and so on, permitting the easy withdrawal of defective or modified parts. There is nothing new in the method; it is merely the application of general engineering principles to an ordinary distribution problem.

Mass Production of Small Arms Ammunition

By

H. W. STARKWEATHER

IN the March-April number of ARMY ORDNANCE there appeared an article by Col. J. Mayhew Wainwright, entitled "Mass Procurement." This should be read by every member of the Army Ordnance Association.

The recent survey of the Cincinnati Ordnance District, which necessitated consideration, by the writer, of some questions as to the capacity of our company, for war purposes, had already awakened several of us to the large amount of work which would be required to get our plant back to a war basis, but Colonel Wainwright's article brings home very forcibly the immense task entailed in completely equipping an army.

While we are only one small unit among thousands that would be required, perhaps a survey of our situation, with a few suggestions, might be of some small interest. Our situation is, essentially, no different than that of any other manufacturer of small arms ammunition, and certainly no one article is more important to an army than ammunition.

The remarks which follow are based on sixteen years of continuous connection with the manufacture of small arms ammunition of all kinds, as well as the manufacture of cannon cases; including plant and product engineering work, and production in three of our five commercial ammunition plants.

Being now connected with The Peters Cartridge Company, the condition of this company in its relation to the manufacture of war ammunition will be considered, as all conditions at the plant are known, but, as stated above, conditions in other commercial plants are probably similar.

Assuming the adaptability of a plant for a certain purpose, one of the first questions naturally asked is as to the character of the organization.

Our entire executive organization has been with The Peters Cartridge Company for years, and therefore it directed the affairs of the company during the entire recent war period, so that experience in the trials and tribulations of war contracts, and any other problems, would be available.

Our factory organization, both that engaged in production and engineering, is second to none; the same applies to our equipment and buildings. We are all Peters' boosters and take pride in turning out quality ammunition, in all lines, with the knowledge that our product will reflect credit on all in the organization.

The above is said, not in a spirit of undue egotism, but to show that commercially we are in a strong position from the standpoint of organization and equipment, and that in spite of this it would be a real "he man's" job to get onto a war basis.

The average man has the idea that an ammunition plant is a place where raw material in the form of brass, lead, powder, etc., is received; put through a few operations to make them into ammunition and then the profits are collected.

In order to show the amount of detail involved in the business of manufacturing ammunition, the following facts are given. Many different classes of ammunition are made, each class requiring entirely different materials and different processing of these materials. The simplest kind of ammunition requires many different operations before being

made ready to go into the gun, and the collection of profits is always extremely difficult, requiring the strictest economy and supervision, both at the plant and in the sales and executive offices.

Every small-arms ammunition manufacturer makes the following general classes of product: Rim fire, center fire pistol, center fire rifle, and paper shot shells. Each class is made in hundreds of calibers and loads, each one of which has its own peculiar characteristics.

Each one of these loads must function properly in every arm chambered for the load; whether or not the blow of the firing pin varies from extremely light to extremely heavy; whether the chamber is small or large; whether the bore and rifling are good or bad; whether the arm is good or bad as regards design or condition.

These loads must not give misfires or pierced primers; must not give excessive pressures; must properly ignite and burn the powder; must give proper velocities; must give satisfactory accuracy or patterns; and many other results, too numerous even to mention.

All of the above-mentioned classes of ammunition are used by an army; the rim fire for training purposes; the center fire pistol for the pistols and revolvers; the center fire rifle for the rifles and machine guns; the paper shot shells for practice at the traps and trench mortars.

The manufacture of each of the various classes requires from thirty to eighty or more operations, consisting of various kinds of operations, with different materials, necessitating a knowledge of: The heat treatment, cutting and drawing of brass, gilding, steel, lead, and cupro-nickel; the treatment and handling of paper; the handling of explosives; the manufacture of many supplies, used in connection with ammunition, etc.

The above gives only a very superficial idea of the problems involved in the manufacture of our various products and gives only a slight outline of the requirements to be met and the organization, equipment and material necessary to the production of satisfactory ammunition. With these facts in mind, we can now turn to the question of preparedness in respect to the manufacture of small-arms ammunition for war purposes.

When the World War broke out, in 1914, the ammunition companies in this country were totally unprepared to handle the volume of small-arms ammunition required by those who later became our Allies. Those who went through the period of plant expansion, with the hurried figuring of capacities, costs, deliveries, and the attendant studies of specifications and contracts preceding the starting of manufacture, know how little these plants were prepared. Those who stuck through the building up of the organizations to run the various plants, know more of what this expansion meant.

Even with all this preparation, however, we know how totally inadequate were our facilities for the production of ammunition for small arms, at the time of our entry into the war. In fact, if it had not been for the early European contracts placed with American manufacturers, it would have been an absolute impossibility to equip our American Army in time to have been of any service to our Allies.

The question of preparedness of the small-arms ammunition plants of this country, at the present time, is a matter for serious consideration. Have we the organization, technical knowledge, buildings and equipment to do as well, or better, than was done in 1914? There is room for considerable doubt as to an affirmative answer to this question.

The Peters Cartridge Company has an excellent peace-time or commercial organization, which could be used as the nucleus of a war organization. To expand to a war organization, however, would necessitate a large amount of training for many people, which would require much time by those who would then be extremely busy individuals.

What about the technical knowledge of our army ammunition? All of the ammunition manufacturers make our army cartridge in small quantities to fill commercial orders, but only incidentally do we know of the development of special ammunition for aeroplanes, tank, tracer and other purposes.

Our buildings are completely occupied by commercial equipment; all equipment for war-time ammunition has either been abandoned or so altered as to be useless for its original purpose.

We are continually improving the quality of our commercial ammunition, and all of this knowledge would be useful in one way or another in case of war, but the only real education in the manufacture of army ammunition is its manufacture under specifications for the Army in sufficient quantities to keep the entire organization familiar with this work, and at least once a year. However, due to certain legal restrictions, it is impossible to let contracts to commercial companies, which would not impose conditions practically forbidding the acceptance of contracts by such companies.

Years ago each company received a contract once a year for several millions of cartridges both rifle and pistol, which served the purpose mentioned in the previous paragraph, but this is not now done, and we are not as well off in this respect as we were in 1914.

This is not a very optimistic view of the present situation, but as we lose those who have had experience in the manufacture of small-arms ammunition for war purposes, it will steadily grow worse, unless something is done. Possibly something is being done, but if so, we have not heard of such action. However, we would like to suggest consideration of the following as a possibility:

While all manufacturers of small-arms ammunition, during the war, followed the same general methods of manufacture, no two were alike in materials, specifications, equipment or tool and gage layouts.

Through cooperation between the commercial manufacturers, Frankford Arsenal, and the proper Government agency, an ideal tool and gage layout could be made, and each operation could be standardized. This would permit of standardization of all materials used in the manufacture of these cartridges by the various manufacturers, thus simplifying the procuring of material.

In the same way, the best equipment for each operation could be selected and proper drawings and records made and kept on file for use in case of war. This would thereby simplify the building of equipment, and would also make it interchangeable between different plants.

Then make a plant layout for a predetermined unit so that it would not take time to work out the plans for buildings that would be necessary without standardized methods of manufacture. An organization could even be laid out, so that it would be known definitely what number of men, and their training, would be required.

We also believe that each ammunition manufacturer should have a complete layout of his plant as a war unit, limiting it to the manufacture of as few different articles as possible: i. e., .45 Auto. Colt, or .30 Gov't 06, etc.

The above is along the line of what could be done, and is in line with sentiments expressed in Colonel Wainwright's excellent article. Modern business is based on sound planning, and if the War Department had plans as out-

lined above for the manufacture of all war supplies, 75 per cent of the battle would be won.

We also believe that responsible men in the ammunition business should be kept in touch with all developments in ammunition, for the good of the cause of preparedness, and should really be considered a part of the War Department, in so far as their business is concerned.

While it may be a little off the subject, we might mention that some day, if some of our pacifist reformers have their way, the ammunition companies may be legislated out of business, and Frankford Arsenal would then have to take care of the building up of the ammunition organization and production in case of war. When such time comes we sincerely hope that we are not officers at the Arsenal.

The officers connected with the development of ammunition and the organization at Frankford Arsenal are engaged in work which could not be handled in any other way; certainly no commercial company could keep in touch with the new developments and requirements of the military organization to the same extent that a part of this organization can. We believe that the development and manufacture of all types of ammunition should be carried on at the Arsenal, as is now done.

However, we believe that in case of war, the real production of ammunition will be at the commercial plants, and that most of the real technical knowledge required for quantity production will be found in commercial organizations. This must be true, because a man in commercial life, to be a success in his line, gives his whole life to his business, while the officers, due to the nature of *their* business, do not devote their lives to the manufacture of ammunition. Therefore, it is essential to the safety of the country that the ammunition manufacturers of this country be kept in close touch with the Government developments and requirements.

The U. S. Aircraft Machine Gun

By

WALTER T. GORTON

THE development of the use of machine guns for arming aircraft, dating from the latter part of the World War, has been discussed in previous articles in ARMY ORDNANCE. For general data on this subject the reader is referred to the issues of January-March, 1921, and May-June, 1922.

Practice adopted in connection with the use of machine guns for this purpose soon crystallized into two separate branches, each requiring a weapon of differing special characteristics. One of these pertained to the arming of the observer with a gun adapted to be aimed in any direction and to be used principally as a defensive weapon. The other had to do with arming the pilot by providing a gun which could be operated effectively without interfering with control of the plane. The observer's gun soon became known as the flexible gun, and that of the pilot, as the fixed or synchronized gun. The latter weapon derived its name from the fact that the best arrangement for it was found to be fixed with respect to the plane, located on or beneath the cowling and pointed to fire straight ahead through the field swept by the propeller. In order to prevent firing into the propeller blades, a regulating mechanism was adopted to control the fire of the gun with relation to the propeller, and this mechanism is known as the synchronizing gear. As soon as these two different uses for machine guns were at all clearly recognized, much evidence presented itself to show that each would require very different types of guns for best results. Up until the present, this idea has governed the development of aircraft guns, but there has been considerable thought given to the possibility of the use of a single gun for both purposes. The Lewis has been our only flexible gun, and for fixed guns we have had in turn the Vickers, the Marlin, and the Browning.

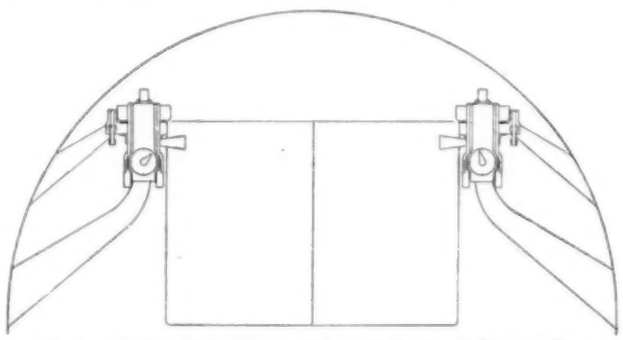


Fig. 1. Diagram of Installation of Twin U. S. Aircraft Machine Guns

The requirements for a satisfactory synchronized gun are in some respects considerably more severe than that for an efficient flexible weapon. This is true because of the peculiar circumstances under which a synchronized gun must operate and especially the necessity that it be adapted to efficient installation with relation to all parts of the machine which are affected by it. All of the guns used for this purpose have been adapted from existing ground guns. None has been especially designed for this particular purpose, and consequently none has been entirely satisfactory. This fact was recognized in the plans for the design of the U. S. Aircraft Machine Gun which has been developed to meet, in as far as possible, the requirements for an ideal synchronized gun of standard caliber.

This gun is intended primarily for synchronized use, but since standardization upon one type of gun suitable for use both as a fixed and flexible weapon is a very attractive possibility, the design has been planned to be suitable for flexible use, in as far as practicable, without sacrifice of utility in its major rôle or incompatible with its characteristics as a belt-fed weapon.

The first step in working out the design was an analysis of the requirements for a gun of this kind. The two basic requirements are: positive, reliable operation under all conditions of flight, and reasonably high rate of fire.

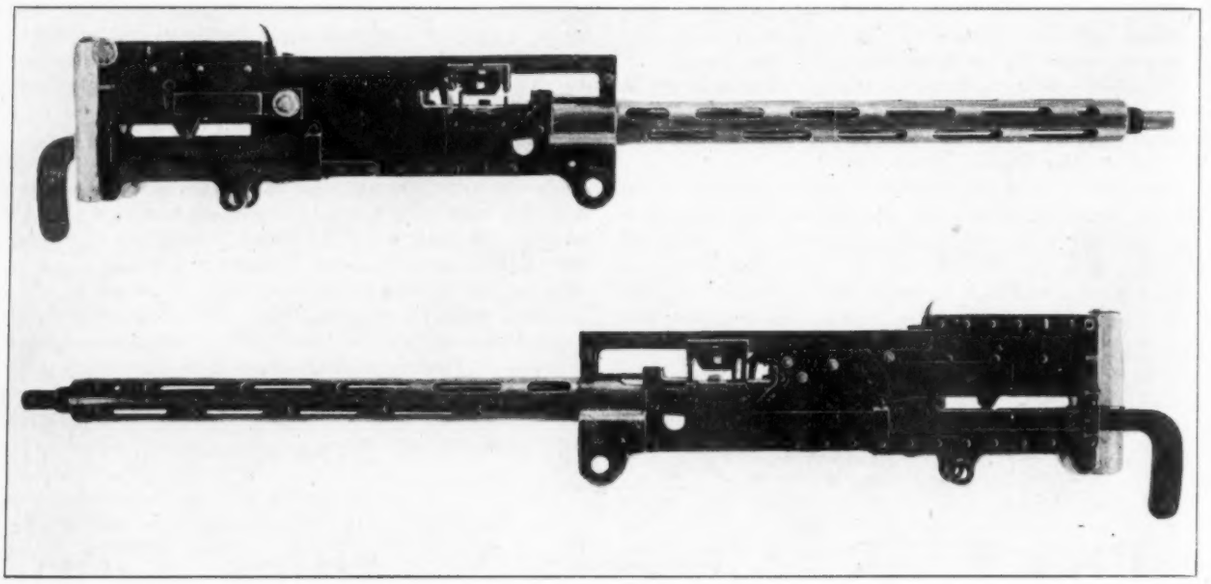


Fig. 2. Right-Side (above) and Left-Side (below) Views of First Model (1921) U. S. Aircraft Machine Gun

Others, such as light weight, simplicity, and compactness of construction, are important, but are not unusually so. The requirement that the gun adapt itself readily to efficient installation, particularly in pairs, is of governing importance. It involves provision for symmetrical arrangement of the entire gun mount, ammunition boxes and chutes, ejection chutes, and synchronizing gear with respect to the central vertical plane of the machine. The accompanying sketch (Fig. 1) illustrates the advantages of this symmetrical installation. To obtain this, it is necessary that the gun be adapted for feeding from either side (belt feeding assumed as the only means of providing sufficient firing capacity), ejection of belt links from either side and cartridge cases from the bottom, location of the trigger motor on either side, and operation of the handle for opening the breech by hand on either side. Another important requirement is that the operating parts be removable for cleaning and inspection without disturbing the adjustment of the synchronizing gear; and, to complete the list, it is essential that all these features be obtained without unwarranted complication of parts and especially without the use of extra or alternate parts or sets of parts.

After analysis of the requirements to be fulfilled by the new design, the next step was to determine the mechanisms which offered most promise for each feature, and then to reconcile them sufficiently to permit their use in one gun. From the first, it was decided that no attempt would be made to follow any existing design for the sake of preserving interchangeability or for any other reason. Due to the severe requirements imposed, it was considered necessary that an entirely new start be made in the attempt to satisfy them. However, in as far as possible, features of existing weapons which had proven practicable were utilized in building up the design. There is very little in this or any other known recent firearm that is basically new. Perhaps the features that come nearest to this classification are those relating to right or left hand feeding and operation of the trigger motor. The good points in all known designs which gave promise of usefulness were freely adopted, but very few could be utilized in detail without considerable modification. Correspondingly, many of the features of this design have been incorporated in the designs of other weapons, notably the .50 caliber aircraft machine gun. It is scarcely necessary to state that the Browning machine gun has furnished more serviceable features than any other design.

A curious fact developed by this study is that the required provision for right or left hand feeding and similar arrangements operated invariably in the direction of simplicity in construction rather than the reverse, as might have been expected. The reason is obvious upon consideration: only parts of simple form could possibly be adapted to function reversibly in corresponding right or left hand locations. The result is that the new design compares favorably in number and complication of parts with former designs which do not include the reversible features. One point of disadvantage, however, must not be overlooked: with provision for assembly in either of two ways, wrong assembly is possible. It is believed that this will not be considered serious by the Air Service, as reasonable training in operation of the gun would reduce the chance of improper assembly to very slight proportions.

Upon the basis of the requirements outlined above, plans for a preliminary design were formulated early in 1920, and in September, 1921, these were advanced sufficiently to permit construction of a model at Springfield Armory. This model was completed in December of that year and its test was at once begun. This test revealed numerous weaknesses, but, nevetheless, the gun, known as the U. S. Aircraft machine gun, Model of 1921, fired over 10,000 rounds, and is still in firing condition. Illustrations of this model are reproduced in Fig. 2. The results of this test, while showing the necessity for numerous changes in design, indicated that satisfactory performance could ultimately be expected.

At about this time a new requirement developed. This was the desirability of arranging the sear mechanism so that a thrust of only about four pounds would be sufficient to release the sear instead of the usual sixteen-pound

thrust. The object of this reduction was to permit the use of synchronizing gears not capable of delivering the heavy thrust, and to lessen the strain and likelihood of getting out of adjustment, regardless of the gear used. The result was a considerable modification of the sear mechanism for the next model, but the thrust was cut down to four pounds with even more dependable holding of the sear, and the feature of operating the sear mechanism from either side of the gun was retained. The only added parts required are one spring of flat tapered section and the holding pin to which this spring is riveted. In subsequent tests this sear mechanism has given perfect satisfaction. A target fired with the second model gun in a synchronizing test is reproduced in Fig. 3, and reference to this figure will indicate the uniformity of the sear action. A sear mechanism of the same principle has been adopted for the Garand rifle.

Fig. 3. Target fired in Synchronizing Test of Second Model Gun after 20,000 rounds

Construction of the second model gun embodying the improvements found necessary in the test of the first model was completed by Springfield Armory in June, 1922. Illustrations of this model, known as the Model of 1922, are shown in Fig. 4. Preliminary tests revealed the necessity for correction of a few minor interferences, but when these were made, very promising functioning was at once obtained. A total of 10,000 rounds was fired in this test with two minor breakages requiring replacement. During the test frequent changes of the direction of feeding of the belt were made, but without effect upon functioning.

Following this test, the gun was tested at Aberdeen Proving Ground and later at McCook Field, in both of which tests promising results were obtained. It has been returned to Springfield Armory and after a total of over 20,000 rounds of firing is still in perfect functioning condition and is the standby of the Experimental Department in tests in which the value of results obtained are particularly dependent on reliable functioning of the gun. Some minor repairs on it have been necessary, but these have been mainly to correct imperfections in design rather than to improve any inherent weakness of construction. Development of the design is now considered practically complete except that it is intended that eventually a rounds counter will be built into the back plate for the convenience of the pilot in keeping track of his ammunition supply. The weight of the gun is almost exactly twenty pounds. Its rate of fire was planned to be about 1,000 rounds per minute, but in tests of the second model this rate was not attained. However, it is anticipated that there will be no difficulty in increasing it to any desired extent not exceeding 1,200 rounds per minute without other than very minor adjustments in the gun design.

In order to facilitate mounting, numerous standardized features, such as the size and location of the mounting pins, have been retained. When arranged for feeding from the left, the gun may be installed in a mount for the Browning aircraft machine gun with practically no changes in the whole installation except that the necessary greater width of the cover must be accommodated.

In order to provide for use as a flexible weapon, the

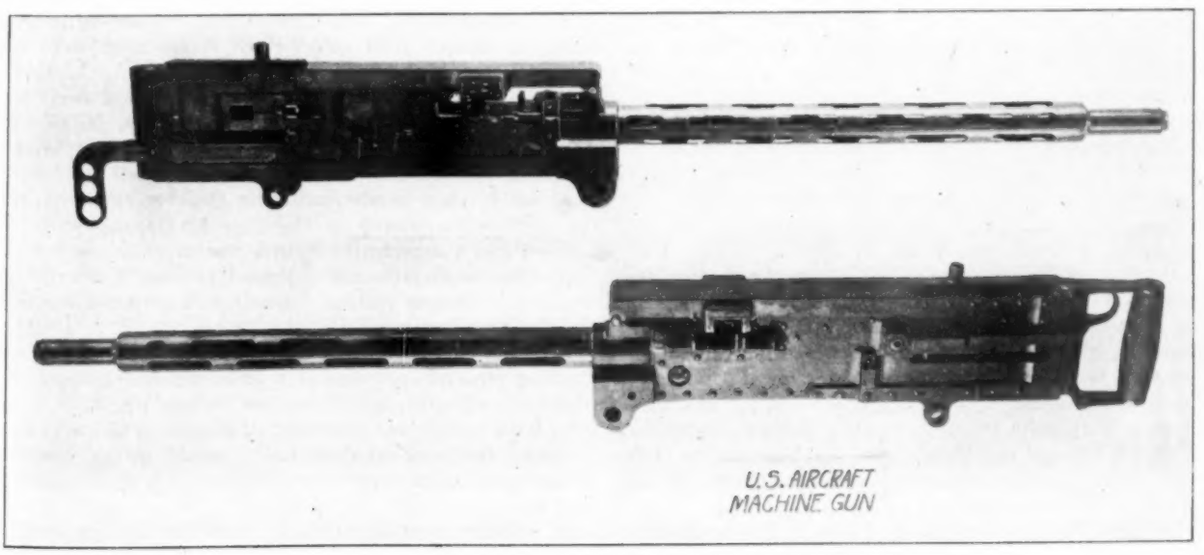
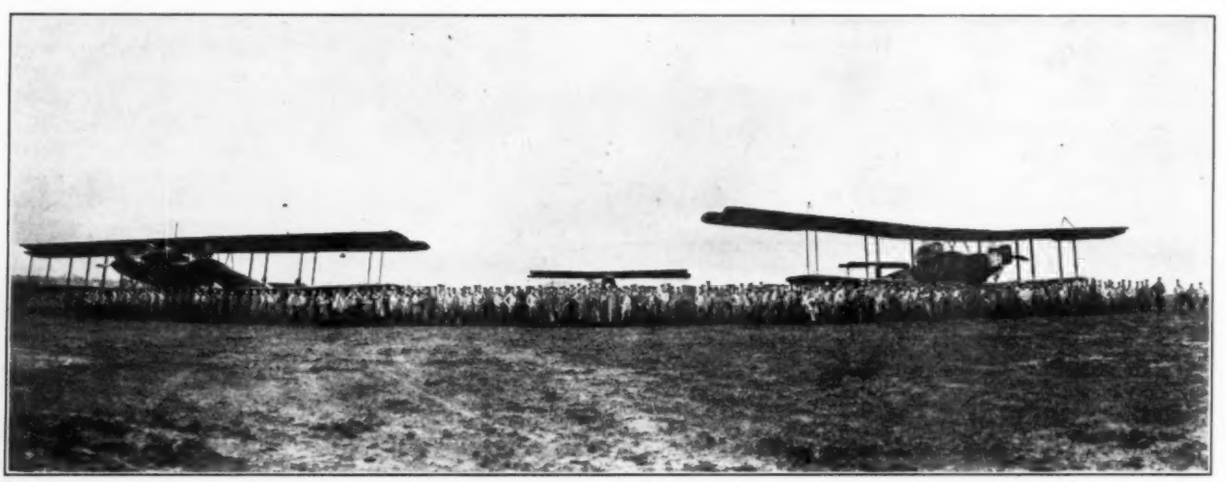


Fig. 4. Right-Side (above) and Left-Side (below) Views of the U. S. Aircraft Machine Gun

gun has been made as compact as possible, and is equipped with a spade grip and trigger mechanism, as shown in Fig. 2. A compact belt-box style of magazine holding 100 rounds, and an adapter to permit of mounting on the standard flexible mount has also been designed, but no sample has yet been constructed. There is a possibility that this arrangement, particularly for twin guns, would be useful for anti-aircraft installation as the symmetrical mounting permitted by the right or left hand feeding would facilitate balancing on a post mount and thus improve the scope of the weapon.

In developing this design, every effort has been made to obtain the mechanical features considered necessary by construction well adapted for manufacture. To this end, with but two or three minor exceptions, only plain carbon steels are used, and the number of different kinds of steel is reduced to the minimum compatible with good results. All rivets are standardized at .156-inch diameter, and wherever possible have a standard oval countersunk head. Pins and holes are made with the least practicable variety of diameters. Springs are all either flat or helical and are made in as little variety as possible. Only two sizes of wire are required for all helical springs, and each size of wire is coiled to the same pitch for all the springs formed from it, except that those for torsional loads are coiled solid. Wherever possible springs are identical. All cotter pins are of the same diameter. All threads are identical except in diameters. Basic dimensions, wherever possible, have been kept to even fractional or decimal parts of an inch, and tolerances made plus for inside, and minus for outside, dimensions. Tolerances which do not involve a fit, such as location of a hole or stud, are usually made plus or minus, and allowances are ordinarily made minus from the inside minimum. Radii of corners, fillets, and cuts generally have been standardized in so far as practicable upon a small number of even fractional dimensions. All parts are designed for complete interchangeability in quantity production. In as far as can be foreseen, no feature of this design offers any special difficulty in manufacture and the cost of production should compare favorably with that of present models.



The Cadets Visit Aberdeen

THE future generals of the Army, the first class of cadets of the United States Military Academy, visited Aberdeen Proving Ground April 29 and 30, and May 1, 1923. They saw the big guns fired, watched the bombers drop demolition bombs, and had explained to them all the operations and uses of the latest developments of ordnance. The visit was in charge of Major C. G. Mettler, Professor of Ordnance and Gunnery at the Military Academy, who arranged the trip so that the classmen might have a practical demonstration of the theories and principles of the classroom.

Accompanying the class were the instructors in the Department of Ordnance and Gunnery, Major P. C. Callock, of the Department of Tactics, and several officers of the Department of Civil and Military Engineering, including Lieut. Col. William A. Mitchell, Professor of Civil and Military Engineering.

After a lecture by the Commanding Officer describing the Proving Ground and its purpose, the time of the visit was divided in giving instruction and demonstrations by the Proving Ground personnel.

The Main Front, Aviation Field, and Water Ranges were also visited. On the Main Front the new units of field artillery, namely, 155-millimeter gun, 8-inch howitzer, Model 1920 materiél, 4.7-inch gun, 155-millimeter howitzer, Model 1920 materiél, 75-millimeter gun, and 105-millimeter howitzer, Model 1920 materiél in comparison with the 75-millimeter Model 1897 and 1916, 3-inch A. A. Model 1920, and the re-chambered 105-millimeter howitzer (German); ammunition consisting of propellants, projectiles, primers, fuzes, cases and bags were shown and explained. At the Aviation Field a complete layout of all the American and foreign bombs including their components and the various aeroplanes at the Proving Ground were exhibited, and a descriptive lecture was given on each type. The same procedure was followed at the Water Range where the various railway mounts and seacoast artillery and equipment were exhibited.

In order to more clearly bring out the lectures, the Proving Ground carried out a most interesting program of firings with machine guns and various pieces of artillery, both mobile and railway. A demonstration was also given of new and experimental types of trucks, trailers, self-propelled gun mounts and other types of automotive materiél.

It is believed that this visit, forming the culmination of a course of theoretical instruction, was of considerable value to the class.

Our Service Cartridge

By

GERALD CAHILL

WE are so accustomed to the service cartridge that we rarely stop to consider the amount of thought, ingenuity, time and labor required to bring it to its present stage of apparent perfection. The United States Government service cartridge, in conjunction with the service rifle and machine gun, was a potent factor of our success in the late war.

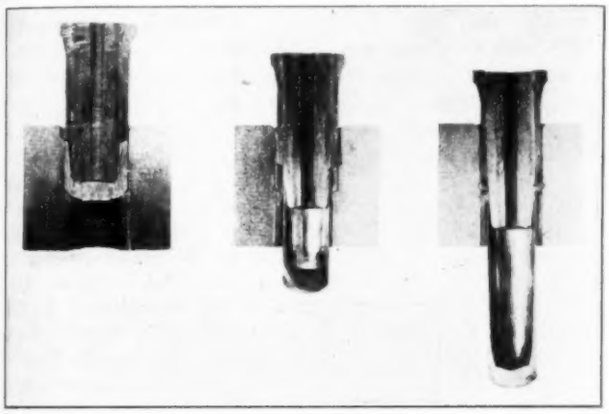


Fig. 1. Three Stages of Shell Extrusion—Hooker Process

How many of us who are accustomed to the handling of the service cartridge have ever compared it with the paper cartridge in use during the Civil War? At that time a cartridge consisted of a bullet and the powder charge encased in a paper envelope, the percussion cap being a separate unit. The combination of percussion cap and cartridge had been used to a slight extent in England. It consisted of a percussion cap inserted in a steel head attached to which was the cartridge case made from wrapped stripped brass into which the powder charge and bullet were inserted.

About 1866 the manufacture of a full metal cartridge case was started at Frankford Arsenal. It was a rim-fire cartridge, the case of which was made from gilding metal, 95 per cent copper and 5 per cent spelter. Later on, a center-fire cartridge was developed in which the percussion element was placed inside the cartridge directly under the center of the head. The next step in its development was the inserting of the percussion cap on the outside of the head similar to present practice.

As reloading was then one of the special claims for the metallic cartridge, gilding metal had to be used as brass was attacked and deteriorated by the large amount of fulminate then used in the percussion cap. Extraction difficulties made it necessary to develop a brass cartridge case, the inside of which was coated with shellac to prevent the deterioration of the brass by the fulminate.

There was very little improvement in the cartridge from 1875 up to the development of smokeless powder and the adoption of the Model 1898 .30 caliber Krag rifle. The manufacture of a cartridge for this rifle necessitated the development of a new type of cartridge-making machinery. What was learned from this arm led to the development and adoption of the Model 1903 Springfield rifle. The cartridge for this rifle used the same bullet as the Model 1898 Krag until the present 150-gr. Spitzer bullet was adopted. This bullet necessitated a slight change in the rifle chamber and shortening of the cartridge case .07 inch, the remodeled cartridge being called the Model 1906. Our experience in the war brings out the advantages of a heavier bullet for this cartridge, but otherwise there seems to be no opportunity to improve this very efficient cartridge for rifle use.

There had been no marked improvement in cartridge manufacturing methods since 1903, but the World War necessity for large quantity production led to the adoption of a new method of cartridge-case manufacture. This is known as the Hooker Extrusion process. Originally it had been developed for the manufacture of copper radiator tubes. The United States Cartridge Company saw in it possibilities for cartridge-case manufacture and developed it to such an extent that the Hooker presses were turning out over 2,000,000 cartridges per day when the Armistice was signed.

The conventional method of making a cartridge case is to first stamp out a shallow cup from strip brass .130″ thick. This is annealed and passes through a series of five or six redrawing operations with annealing and washing between each operation, after which the shell is trimmed to length and made ready for the final forming operations. By the Hooker Extrusion process, the shell, by one stroke of the machine, is extruded from the annealed cup above mentioned to a length requiring only one redrawing operation to prepare it for the final forming operations. In cartridge cases made by this process the metal shows a better physical structure than when made by the conventional redrawing method and when firing an endurance

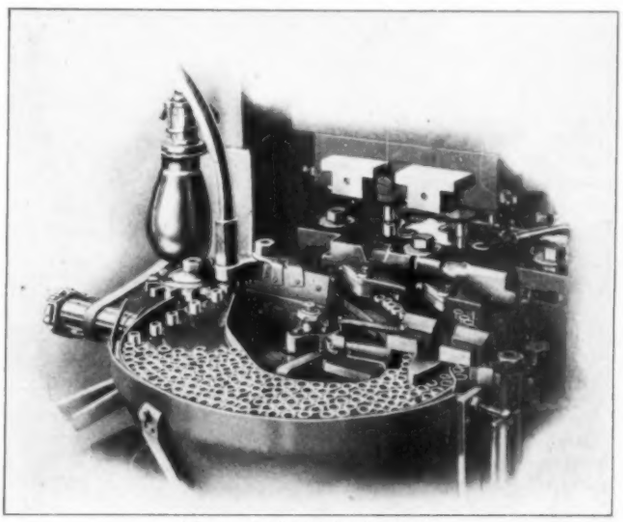


Fig. 2. Dial of Extrusion Press

test cartridge cases have been reloaded and fired 87 times without fracture. There was also a distinct advantage in the use of this process for quantity production in time of war due to the relatively small mechanical equipment and floor space required.

The war has taught us many lessons, the principal one, to my mind, being preparedness. We point with pride to

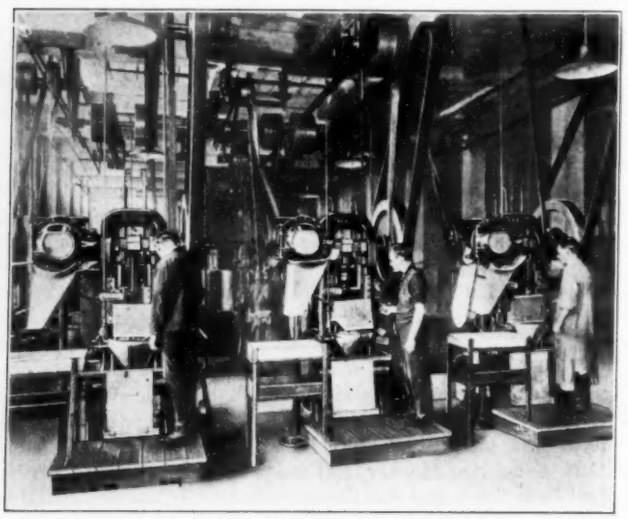


Fig. 3. Extrusion Presses, United States Cartridge Company

our great achievement in getting our troops into France in so short a time, but the fact that the Ordnance Department was supplied with a sufficient quantity of ammunition to meet its requirements is apt to mislead us by giving a false impression of the time required to go from a peace-time basis to quantity production of munitions necessary to meet war requirements. Cartridge manufacture requires a large amount of machinery and trained, skilled operators. This type of machinery cannot be built over-night.

The first Allied contracts for military cartridges were received in this country about September, 1914, and steps were immediately taken by the commercial cartridge manufacturers to enlarge their plants to meet these orders; yet, by September, 1915, their combined production had reached only about 75,000,000 cartridges and their combined 24-hour daily production approximately 1,500,000 cartridges.

When we entered the World War, our Government had in reserve approximately 200,000,000 rounds of .30-cal. cartridges, and, due to the fact that the private companies had been supplying the Allied governments with ammunition, their military cartridge-making equipment was quickly changed to the manufacture of our own service cartridge in large quantities. As a result, within six months after we entered the war, we had manufactured about 150,000,000 rounds and had reached a combined daily production of approximately 6,000,000 rounds. By the time the Armistice was signed approximately 2,800,000,000 rounds had been manufactured and combined production had reached 12,000,000 cartridges per 24-hour day.

In case of hostilities it is doubtful if we will be able to get into production any more rapidly than we did in 1914. Frankford Arsenal has a moderate-sized equipment. The military cartridge manufacturing equipment of the private companies has been dismantled and sold so that their present combined daily capacity would be less than 750,000 service cartridges per day of 24 hours. It is doubtful if the machinery manufacturers could build cartridge-making machinery any more rapidly than they did in 1914. Our Ordnance Department is alive to this situation. It has under way the mobilization of war industries which will be of great help in getting manufacturers into production in case of emergency, but before we can make ammunition we must have the equipment and knowledge to operate it. A reserve equipment at our arsenals and service cartridge manufacturing units at all private cartridge plants wherein part of our reserve ammunition should be manufactured yearly would be beneficial in case of another emergency.

Recoil Mechanism, 75-mm. Gun Carriage, Model 1923-E

A proposed design of recoil mechanism for the 75-mm. Gun Carriage, Model 1923E, has been laid down in study form in the Artillery Division of the Ordnance Office with the view of increasing the firing stability of this carriage. A brief discussion of this new design should be of interest to the readers of ARMY ORDNANCE.

In principle this design is identical with that laid down for the 75-mm. Pack Howitzer Carriage, Model 1923, Type A.

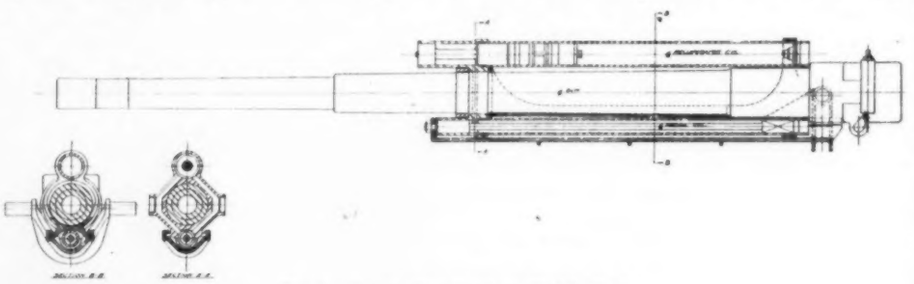


Fig. 3. 75-mm. Gun Carriage, Model 1923E

The mechanism consists of a recuperator cylinder and a recoil cylinder secured to a diamond-shaped forged steel yoke at their front ends. The gun is passed through a round central hole in the yoke with the recuperator cylinder arranged directly above and the recoil cylinder below the gun. The clips have been removed from the gun and made integral with a cast steel sleigh which is secured to the yoke at the forward end and also provides seats for the rear ends of the two cylinders. The yoke bears on a machine collar on the gun jacket near the forward end while the sleigh bears in a like manner at the rear. The mechanism being assembled as a unit is slid over the gun and fastened in place with a round nut threaded onto the gun jacket in front of the yoke, clamping the mechanism between the round nut and the forward face of the breech ring. Lugs on the sleigh engaging slots in the breech ring prevent rotation of the gun due to rifling. The interior parts of the two cylinders are of the modified Puteaux type similar to the pack howitzer mechanism mentioned above. The length of recoil is unchanged, namely 42 inches, and constant for all elevations. This mechanism contains no oil pump or oil gauge, the amount of reserve oil being determined by purging and refilling. The entire mechanism and the gun, with the exception of the recoil piston and rod, move in recoil and in-guides formed in a trough-shaped cast steel cradle supporting the mechanism, and to which the recoil piston rod is attached at the front end. The trunnions are an integral part of the cradle. This mechanism, together with the cradle, would weigh approximately 50 pounds more than the original recuperator unit designed for this carriage.

The Surveillance of Ammunition

By

C. H. MORGAN

"ALL high explosives are, therefore, subjected to certain standard tests with a view to determine their stability, and especially the probability that they will not decompose in storage. * * * A sample of each accepted lot of powder is kept at the works of the manufacturers where it is observed from time to time and tested." ("Military Explosives," Weaver.)

Ammunition is a subject which is neglected in peace and which attains its true importance only in time of war. Every available industrial resource is mustered by a nation at war to support and make effective its forces in the field. A shortage of munitions becomes a vital problem to the state. In the World War, Mr. Lloyd George became Minister of Munitions, and later, Prime Minister of Great Britain, through the adoption of a live and energetic munitions policy. In the early part of 1915, the success of the British arms in France was greatly imperiled due to the breakdown of the ammunition supply. Unfortunately, with the advent of peace, the importance of ammunition is forgotten and the limited funds appropriated prohibit the maintenance of a large ammunition reserve.

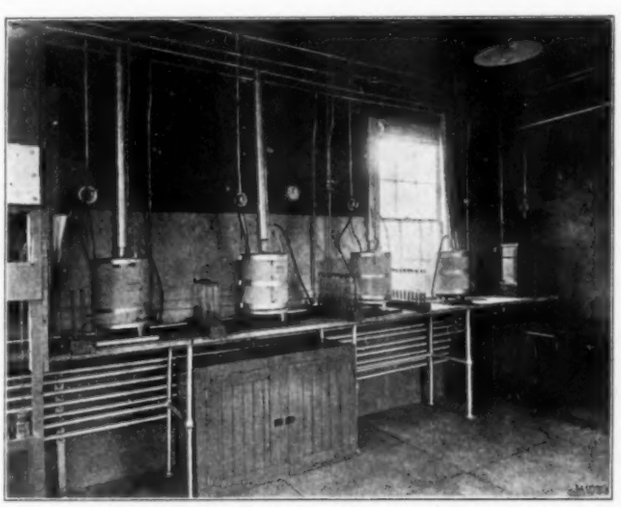


Fig. 1. Interior of Stability Laboratory, Picatinny Arsenal, Showing 135° Heat Test Baths.

For adequate preparedness, sufficient reserve stocks of ammunition must be maintained to supply the field forces until new production can reach the front in an amount equal to the expenditures. These stocks, with the best of care, will not last indefinitely but have an estimated life of about fifteen years. Therefore, it is necessary to establish a definite replacement program. As a result of the World War, large stocks of ammunition were left on hand, in general, sufficient to meet our needs until an adequate production can be attained. It is the present plan to initiate the replacement program of these stocks beginning with the year 1928.

The importance of ammunition and of its maintenance is, therefore, readily apparent when translated into a medium of dollars and cents. The estimated value of the present reserve stocks of ammunition is somewhat over one-half billion dollars. The total Ordnance estimate of funds for the fiscal year 1924 amounts to $5,886,700. Of this amount approximately $2,600,000 is for ammunition purposes. When the replacement program planned for 1928 is initiated approximately five-sixths of the entire Ordnance appropriations will be required solely for ammunition projects.

By surveillance of ammunition is meant that care which is maintained over ammunition to insure that troops receive the best and most serviceable ammunition possible, and which enables the Ordnance Department to fulfill its function of service to the line. This surveillance includes chemical and physical tests, inspection of complete rounds of ammunition and components, stability in storage, and of the utmost importance—functioning when fired. The surveillance of ammunition begins with the rigid tests and inspections to which ammunition is subjected before acceptance by the Ordnance Department. This surveillance continues throughout the life of the ammunition and extends until the ammunition is finally fired or destroyed. In fact, it may even reach beyond this point and cover the disposal of duds or control the methods employed in breaking up ammunition for salvage purposes. The acceptance tests and examinations prescribed at Government arsenals in the manufacture of ammunition will, in time of war, be carried out at commercial plants by Government inspectors.

The purchase of raw materials, such as cotton, acids, etc., is governed by standard specifications, and it is a function of the manufacturing establishment to verify that all raw materials purchased measure up to these standards. This verification is a laboratory process and consists of a chemical analysis of the cellulose, acids, and other raw materials. After a lot of powder is manufactured and submitted for acceptance it is subjected to a series of tests, which can be generally classified as (*a*) chemical and (*b*) physical. Chemical tests of smokeless powder include: Determination of moisture and residual solvent, 135° C. stability test, the 65.5° C. surveillance test, etc. Physical tests include: Measurements of grains, compression tests, and ballistic tests. In the case of high explosives, such as trinitrotoluene, the tests include determination of melting or solidifying points, ash, solubility, acidity, etc.

The ballistic tests of ammunition are conducted at the proving ground. The powder must give the service velocity within specified limits of maximum pressure and weight of charge. For a group of three rounds fired under standard conditions with a charge to give the service velocity, the variation from the mean velocity and the pressure variation must not exceed a fixed percentage. The maximum pressure obtained with a full charge must be safely within the strength limit of the gun. The detonation of high explosive shell must be complete and of a high order. The

shrapnel case must be sufficiently strong to resist fragmentation so as to throw out a cone of lead balls when exploded. The fuse must give satisfactory results within the limits of the specifications covering their manufacture and must produce no failures.

Fig. 2. Interior of 65° C. Surveillance Chamber, Picatinny Arsenal.

Lots of ammunition, which satisfactorily meet the foregoing tests are accepted and released by the Manufacturing Service to the Field Service for storage and issue. The Manufacturing Service, however, retains at Picatinny Arsenal a sample of each powder lot. This sample is kept under continuous surveillance at a constant temperature and as soon as the powder deteriorates beyond a point of safety, the Field Service is immediately advised and all remaining powder of that lot is withdrawn from service.

Under normal conditions the ammunition is, after acceptance, moved from the manufacturing establishment to Field Service storage depots. Here the various components that go to make up a complete round are stored in the specific type of storage provided for that purpose. Surveillance of local storage conditions is extremely important. Ammunition maintained under proper storage conditions at one place may be perfectly safe and serviceable, while ammunition of the same lot stored in another section of the country under less favorable conditions may become very dangerous. The test samples kept at Picatinny Arsenal cannot always warn of ammunition deteriorating because of variation in local conditions.

There are two main factors which determine the stability life of ammunition and especially of propellants, namely: Temperature and moisture. As an example of the former, the deterioration in one day's storage at 100° F. is about equal to that of one year's storage at 0° F. Moisture absorbed by powder decreases the pressure, and consequently the range obtained, and also increases the rate of decomposition. At low temperatures, in proper storage, the stability of smokeless powder is satisfactory. The rate of decomposition rises rapidly with an increase in temperature, and at temperatures in excess of 100° F. the life of powder is greatly decreased. Exposure to moisture during storage increases the volatile content and lowers the muzzle velocity for a given weight of charge. Exposure to high temperature will decrease the volatile content, and increase the muzzle velocity. Under certain conditions, exposure to the atmosphere may produce both of these conditions which may, to a certain extent, tend to neutralize each other. In general, however, the result is to cause great irregularity in muzzle velocities. Therefore, to obtain uniform ballistic results and to prolong the stability of powder it is necessary that it be kept in absolutely air-tight containers and be not subjected to high temperatures.

The surveillance of ammunition after release to Field Service is supervised and controlled by a Chief Surveillance Inspector in the Office of the Chief of Ordnance. Depot surveillance inspectors are assigned to the ammunition storage depots and operate as a depot force to carry out the instructions of the Chief Inspector. The importance of this work is becoming more apparent each day, and it has recently been decided to carry the surveillance of ammunition one step forward, that is, direct to the using service. The surveillance of ammunition in the field will be the function of Corps Area and Department ammunition foremen. A group of especially selected men is now undergoing a special course of training at Picatinny and Frankford Arsenals. Upon satisfactory completion of the course these men will be assigned to the Insular and Panama

Fig. 3. Temperature Control and Recording Clocks for 65° C. Surveillance Chambers, Picatinny Arsenal.

Canal Departments and to all Corps Areas with the exception of the three inland Corps Areas, the fifth, sixth and seventh. In these Corps Areas the armament foremen will be given the special course of training and they will function as ammunition foremen in addition to their present

duties. Thus the surveillance of ammunition after manufacture will be controlled in the depots by surveillance inspectors, and throughout the service by the ammunition foremen. All surveillance will be centralized in and directed by the Chief Surveillance Inspector in the office of the Chief of Ordnance.

The general duties of a Chief Surveillance Inspector are:

(*a*) To initiate and supervise the improvement of present surveillance tests; to revise surveillance regulations; to interpret results of tests and to take action to withdraw from service ammunition which has deteriorated beyond a point of safety.

(*b*) Initiate and supervise tests of the safety of present methods employed in the storing, handling, and shipping of ammunition; to revise regulations involved in such tests; and to inspect ammunition depots to insure that safety regulations are understood and complied with.

(*c*) To assist in conducting firing tests of accepted ammunition by selecting ballistic samples for test purposes; to interpret results of tests, and to take action on lots that fail to pass ballistic tests.

During 1922, firing tests were conducted on all lots of mobile artillery ammunition in storage. The tests followed in a general way the ballistic acceptance tests prescribed in Ordnance specifications. As practically all the ammunition on hand was manufactured during the war it was necessary to determine to what extent it was dependable, and its present condition, and to obtain data which would serve as a safe guide as to its future behavior in storage and in service. This ammunition is subject to progressive deterioration, especially through chemical decomposition of the powder or explosive. One or more parts of a round may so deteriorate as to cause a premature explosion in the gun when fired. Therefore, it is advisable, from time to time, to conduct actual ballistic firing tests on all ammunition.

Fig. 4. Storage Magazines for Master Samples of Smokeless Powder, Picatinny Arsenal.

The Navy Department conducts such tests every three years. The present plan of the Ordnance Department, contingent upon receiving the necessary funds, is to inaugurate in 1924 a fixed policy of conducting ballistic tests of all ammunition at the rate of one-third of the entire stock each year. The value of these tests is evident, for the Ordnance Department will be enabled to issue for immediate use ammunition which has a limited stability life, and to retain in storage ammunition that is showing the most satisfactory stability.

The duties of depot Surveillance Inspectors include the supervision of the local storage and testing of smokeless

Fig. 5. Interior of Storage Magazine for Master Samples of Small Arms Powder, Picatinny Arsenal.

powder, high explosives, and loaded ammunition; the making of appropriate stability tests on all smokeless powder and high explosives suspected of being unstable or of having been exposed to unusual storage conditions; and the inspection of explosives in storage with a view to determining stability conditions. These inspectors are intended to be technical advisors to the commanding officers of the storage depots, and are held responsible on all matters pertaining to the handling and storing of explosives and ammunition. They are required to make frequent inspections of all storage conditions, and all work connected with the handling or storing of explosives and ammunition, as well as to insure that the regulations for safety are being strictly enforced. Laboratories are provided at the storage depots, with all necessary equipment for conducting the prescribed stability tests.

The tests conducted at the storage depots are intended primarily to supplement the surveillance tests which are conducted periodically at Picatinny Arsenal and to give warning of powders requiring special vigilance. The result of the decomposition of nitrocellulose powder is the emanation of oxides of nitrogen, which, if not immediately absorbed by stabilizers, will be given off in the form of gases. These gases are strongly acid, and also possess oxidizing properties, which fact is taken advantage of in the violet paper test as the coloring material of the paper, methyl violet, is decolorized by the oxides of nitrogen. The strips of violet paper issued are of standard size and contain a definite amount of the coloring material. The paper strips, when exposed to the gases given off by the decom-

position of a standard sample of powder, are attacked and will absorb a definite amount of the oxides of nitrogen, while the coloring material in the paper will be changed from violet to a light "salmon pink" color. The time required for this change in color is an indication of the relative rate of decomposition of the powder.

Two kinds of methyl violet paper are made for use in conducting tests of smokeless powder. One known as normal violet paper has a very deep tint and is used in the laboratory for making the 135° C. stability test prescribed by the powder specifications. The other is known as the one-tenth normal (N/10) violet paper and has a paler tint. The latter is used at storage depots to test smokeless powder at normal atmospheric temperatures.

The duties of ammunition foremen will, in general, be similar to those of surveillance inspectors. It will be necessary for them to have the same knowledge of ammunition; to be conversant with its manufacture, and to be especially well informed as to its functioning in service. Surveillance inspectors are more concerned with the stability of large quantities of ammunition in storage, whereas ammunition foremen, although interested in the stability of ammunition, will be more directly concerned with its action when fired. It will be essential for them to be well trained in machine-shop work so that they can intelligently supervise ammunition modification and work orders. The ammunition foremen will have the same duties in relation to ammunition that the armament foremen now have in relation to armament. These duties comprise:

(*a*) Inspection of ammunition in service to determine its serviceability;
(*b*) Inspection of service storage conditions from the viewpoint of safety and suitability;
(*c*) Supervision of the overhauling and modification of ammunition in service, including the work of loading, fuzing, and assembling;
(*d*) Observation of the firing of ammunition in service;
(*e*) Policing ranges after the completion of firing, and supervision of the destruction of duds.

In time of war ammunition will be consumed in great quantities, not only in combat firing, but for training purposes as well. The reserve stocks will be expended, while the industrial resources are being mobilized. New ammunition from the manufacturers will follow the reserve stocks to the firing line. The stability of ammunition and its life in storage will become of less importance. But the work in time of peace on the surveillance of ammunition will bear its fruit in time of war by imparting to the services a knowledge of ammunition and its proper functioning—a work of increasing importance as the types and kinds of munitions multiply and become more technical.

Modern Improvements in Small Arms Powders

By L. C. WELDIN

IMPROVEMENTS in small-arms propellents have gone hand in hand with the advancement of ballistic science. Many noteworthy modifications have taken place both in composition and manufacture since the advent of the first smokeless powders. These replaced the black or brown powders in cannons and in the majority of rifles, revolvers, and shotguns. Cannons are the only class of guns in which smokeless propellents are used exclusively. In other classes of guns there are still used annually large quantities of black sporting powders. For instance, about 40 per cent of all the shot shells sold today are loaded with black powder. In considering improvements, however, the old faithful black powder can be disposed of in a few words, as there has been little, if any, change either in its manufacture or composition. The semi-smokeless powders in use today and the obsolete brown powders are being considered as separate classes.

Modern small-arms smokeless powders may be divided into two general classes—nitroglycerine and nitrocellulose. The former was in use exclusively a number of years before it was determined that successful propellents could be manufactured from nitrocellulose alone without the necessity of adding nitroglycerine. While most of the recent improvements in small-arms powders have been confined to the nitrocellulose class, yet they still fail to meet all of the advantages of the nitroglycerine powders. In fact, in many quarters, it is firmly believed that nitroglycerine or double-base powders will soon replace the nitrocellulose or single-base powders in cannon as well as in small arms. Extensive experiments are at present under way along these lines.

As nitrocellulose powders are the present standard service propellants in this country, consideration in a general way of their improvements will be given first.

When single-base powders were first brought out, or developed, the only means in use here of controlling their rate of burning, or the amount of total energy developed, was by varying the size of grain and the ratio of area to volume of the individual pellet. By this means small pellets with single longitudinal perforations were made for rifles, such as the .30 calibre Springfield, ranging up to large pellets with seven perforations, called multiperforated powder, for cannon. These powders had the same chemical formula and were, therefore, adapted over this large range of uses simply by mechanical manipulation of the size of the powder pellet. In further adapting this grade of powder it was found necessary to vary its potential strength by varying the strength of nitration of the cellulose. This may run anywhere between 12.50 per cent nitrogen to 13.50 per cent for rifle powders, as compared with single-base shotgun powders, usually called bulk powders, which may have the nitrogen strength of nitration as low as 12.10 per cent. It has been found, however, that as the strength of nitration is increased, the temperature of burning is increased and the greater is the erosive effect of the powder on the gun. Therefore, this grade of single-base powders is little different in this respect than that of the double-base powders of low nitroglycerine content.

The ratio of area to volume of the powder pellet of the flake type of rifle powders in use in European countries is controlled by varying the thickness of the sheet of powder from which the small square flakes are cut, simply by adjusting the setting of the rolls; just as we do in rolling sheet iron to obtain varying thicknesses. Such powders are customarily called Ballistite, or Rifle Ballistite, when used in small arms.

Perhaps the next step in the effort to improve the relation of velocity to pressure with the single-base small-arms powder was that commonly called "coating." In this treatment the green grains of powder were surface coated with a deterrent. Camphor was first successfully used for this purpose, whereas dimethyl-diphenyl-urea or centrallite, and dinitrotoluol or trivilene, are in general use at present. The object of this treatment is to produce a grain, the outer layer of which will burn comparatively slowly, in order to keep the breech pressure low, and the inner layers to burn more rapidly, helping to maintain the pressure as the bullet moves up the barrel. Since the deterrent is on the surface, or impregnating the grain slightly, it is said to produce a so-called progressive burning powder. This process of surface coating is similar in many ways to case-hardening steel. The exterior surface of case-hardened steel is harder to work or cut than the interior portions; so are the outside layers of coated powders slower to burn than their inner layers. Even by this method it has been recently proven that, at least in the .30 caliber Springfield rifle, such powders are not as progressive in their burning, nor do they maintain their pressure in the gun as the bullet moves up the bore, as do some of the regular double-base powders.

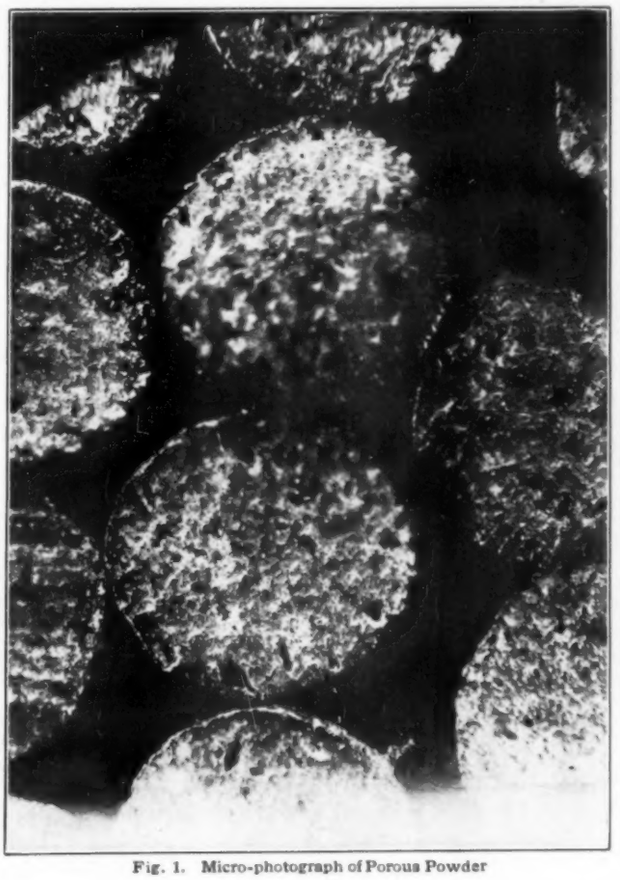


Fig. 1. Micro-photograph of Porous Powder

There are some objections to this type of powder. First, they are, of course, harder to ignite. When they were first manufactured many instances were found where it was necessary to make marked changes in the primers in order to get them to ignite at all. Serious trouble is still being experienced in some quarters with hang-fires and misfires with sporting cartridges where this powder is being loaded. Second, another difficulty is often encountered in getting sufficient powder in the cartridge case to give the desired ballistics. Naturally, the weight of charge has to be increased to at least take care of this extra inert material, and in addition to this the powder is somewhat more bulky and so does not pack as well in the cartridge case. For this reason, it has been impossible to adapt this powder to all the cartridges in existence at present. For instance, in one rifle that comes to mind, the progressive type of pyro powder requires a 20 per cent greater weight of charge for the same velocity than that of the double-base powder. Third, their accuracy is inferior. This is more noticeable at long ranges, such as 1,000 yards. For instance, in the most recent competitive test, these two powders were loaded and compared under exactly the same conditions, in the .30 caliber Springfield rifle, in which the coated powder actually shot 23 per cent larger groups than the double-base powder, as judged by their mean radius. Fourth, they are not as uniform in their velocity or pressure, giving greater dispersion between shots. This trouble may be due to poor ignition and may some day be remedied by a suitable change in the primer. Fifth, they are more expensive to manufacture, requiring several additional processes and handling of the powder.

The surface-coated powders are, however, an improvement, in many respects, over the regular single-base or straight nitrocellulose powders. By this process it is possible to obtain higher velocities for the same breech pressure, although the weight of charge is, of course, higher. It was necessary to improve the single-base powders by this method of treating them, in order to make them approach the velocity and pressure figures developed by the double-base type. In some rifles it is even possible to obtain superior ballistics to those obtained with the double-base powder, although this is rather the exception than the rule.

The Rifle Ballistite type of flake powders can accomplish this same purpose, not only by the coating process, but by rolling sheets of powder of different composition together, so that the quick burning sheet is sandwiched between two slow burning sheets, and then the three are rolled out to the proper thickness and cut into the small square flakes. When such a powder is fired in the rifle the slow burning exterior surfaces generate their gases first, developing a low breech pressure, but as they are consumed, and thus expose the fast burning material, the rate of development of the pressure is increased and the powder is, therefore, said to be progressive in its action.

Recently a novel and ingenious method of making the powder porous has been developed to control the burning and rate of gas pressure generated by the single-base powders. This type of powder finds its greatest field in revolvers, automatic pistols, and shotguns, rather than in rifles. Such type of small arms require a bulky powder, and this clever method accomplishes this as well as giving the powder other beneficial effects. The production of porous powders is very simple. There is incorporated in the powder, while it is in the kneading machines or mixers, a water soluble salt which is later removed by water after the powder has been properly granulated or pressed out in strings and cut to correct lengths to form the size of individual grains or powder pellets desired. This scheme not

only gives control of the ratio of area to volume of the pellets and increases the bulkiness, but as the powder pellets burn in the gun more of these cavities or pores are exposed which are not initial burning surfaces, and thus the rate of burning is increased, making these porous powders progressive in their action. Much has been accomplished by this method and several powders are in use at present in which this principle is used.

The double base or nitroglycerine powders have not had to undergo similar changes in order to adapt them to the different rifles and small arms requirements. It has been found that by varying the percentage of nitroglycerine content, as well as the strength of the nitrogen of the nitrocellulose used, also the size and shape of the powder pellets, or in other words the granulation, this class of powder can be readily changed to meet most any condition found in the small arms field.

Fig. 2. Exterior of Continuous Process Dry House Old Hickory Powder Plant

Some serious attention has been given to improving this type of powder. For instance, it has been successfully demonstrated that flashless agents can be incorporated to eliminate the muzzle flash, as well as to reduce the temperature of combustion. The rifle powders, however, in which this has been tried, have lost something of their accuracy, although this loss is not serious, as their accuracy under these conditions will equal that obtainable with the pyro type.

Double-base powders are also being developed along the so-called non-volatile-solvent lines, in which the usual solvents, such as alcohol, ether, or acetoné are no longer required. This change materially shortens the time of manufacture, as the powder does not require any drying. To drive out the volatile solvents, as well as to recover them and make them fit to be used again, are tedious processes. There is, of course, a large loss from evaporation during the process of manufacture, that is, during the pressing and granulating, when it is impractical to attempt the solvent recovery process. Not only do the non-volatile-solvent powders eliminate this extra expense and loss in time and money, but since there is nothing in their composition which has to be driven out after the powder is formed in its proper granulation, the pellets do not shrink. This shrinking of the grains due to loss of the volatile solvents, when not taken into proper consideration, sometimes causes considerable trouble.

While this type of powder has not yet been adapted to small arms conditions, which is no doubt due to the relative unimportance of this class of arm compared to cannon, it is logically the next step, as it offers numerous advantages. It is non-hygroscopic and can be made flashless. It also has all the advantages of the double-base type of powder over the single-base, and it is being received with marked favor in military circles. The non-hygroscopic feature is of great importance, particularly to the artillery service and to all branches where fixed ammunition is not used. The single-base powders now in general use in this country for this purpose, readily absorb and lose their moisture with atmospheric changes and changes in moisture content even in small percentages have a serious ballistic effect. Non-hygroscopic powders eliminate considerable trouble, in the actual firing, as well as eliminating the necessity of packing the powder in hermetically sealed containers, which must be done with the present propellents, even when they are put up in silk bag charges ready for the gun.

The non-volatile solvent type of powder is readilly manufactured in strip form. This has its advantages not only in ballistics, but also in cheapening the manufacture cost. In the matter of equipment alone it is cheaper to use rolls driven by electric motors than the complicated and extensive apparatus necessary to press the powder out through dies by means of hydraulic pressure. The pressure in the water lines and cylinders of such an installation is maintained around 3,000 pounds per square inch by means of large electric or steam driven pumps working with a system of accumulators. All of this equipment requires careful and constant attention. Repairs are constantly necessary. These are accomplished either by having complete spare units, or by doing the repair work as overtime, that is, at night or Sunday, even during normal production.

There are some disadvantages in manufacturing and loading strip powders. They necessitate considerable handling which, with the granulated type, is customarily carried out by machinery. For instance, in the blending, packing, and loading the granulated powders can be handled almost automatically, while the strip powders cannot be put into large blending towers and run from one bin to another, or rotated in barrels, but have to be kept flat and straight. No doubt some mechanical means could be developed to do even this if it were not for the extremely inflammable character of the material. Consequently, in order to prevent losses by fires and extra hazardousness to the operators, plants manufacturing this type of powder require considerable labor, although since it is not necessary that this labor be high classed or skilled, girls can be used to advantage without prohibitive cost.

Manufacturing processes of small-arms powders have been simplified and improved in many departments. The cost of production, however, has not necessarily been lowered, as the increase in labor rates has more than offset the advantages gained by the improvements. For instance, formerly it was the general practice to drive off the volatile solvents without attempting their recovery; now extensive

solvent recovery processes are in use. The first attempts were made by drawing the air from the dry houses through absorption towers, which method was an improvement, but not entirely successful. Later, the water drying method was developed, requiring considerable less time and working with greater efficiency. By this method the powder is put direct from the granulating machine into solvent recovery cars filled with water, thus eliminating much loss by evaporation. Since the solvents are more readily extracted by a denser medium they will be absorbed by the water in a much shorter time than they would be by the air. The water drying method is now in general use, although it has only recently been combined with the solvent recovery process. Even this improved method is giving place to the alcohol dry process. The time of drying by the old air process, requiring months, has been reduced to weeks, with the water method, and to days with the alcohol process. These improvements, therefore, effect a saving of time and also the recovery of the solvents formerly lost; they therefore have a dual advantage. During the war a great many changes were temporarily made in the manufacture to meet the urgent demand for larger output. Many of these changes were not improvements and were dropped as soon as possible. Owing to the scarcity of raw materials customarily used, substitutes also had to be found, in some instances, to take their places. The substitution of wood pulp for cotton comes in this class. Notwithstanding that successful smokeless powders were made with this material in large quantities, especially in some of the continental countries, their manufacture was discontinued as soon as cotton was again available. Some of the changes proved to have certain advantages and were retained, as for example, the continuous dry process. After the powders have had their solvent-recovery, water-dry treatment, it is necessary to drive off the excess water and bring them down to their normal moisture content. This was usually done by spreading the powder in a thin layer on trays and racking the trays in large dry houses where hot air was circulated. The powder was kept there until moisture determinations showed that it retained the correct amount of water. Then it was removed and ready for the screening and blending process. This necessitated considerable handling and loss of time, difficulties which were successfully eliminated by the construction and installation of a large tower. Here the powder was fed slowly in at the top, passing gradually to the bottom through a strong current of hot air driven upward at a constant rate and with a constant temperature, so that the powder came out with the proper moisture content. This was regulated by the speed with which the powder was permitted to pass down through the tower. This system was found to be very satisfactory and economical to operate.

There is one other improvement in the manufacturing process that should be mentioned here. That is in the method of making the final and preliminary blends of large lots of powder. The usual practice is to haul the powder up in elevators to the top of tall towers and there empty it from bags into large hoppers and permit it to pass out the bottom over spreaders into the next hopper, and so on down through several until it is collected in the last one from which it is packed direct into boxes for shipment. This method has been simplified by building two blending towers and connecting, by means of belt conveyors, the top of each with the bottom of the other. The powder can then be run continuously from one through the other, as many times as desired, to obtain a thorough blend, without necessitating any handling. Another advantage of this system is that the towers do not have to be so tall, nor so large, and usually have only two bins, or hoppers each. Also the powder does not have to be taken by elevators to the top in starting the blending, but is simply emptied from the bags directly on the belt conveyor, arranged for this purpose, at the bottom of one of the towers, and packed in the shipping boxes from the last hopper as before, another decided advancement in the process.

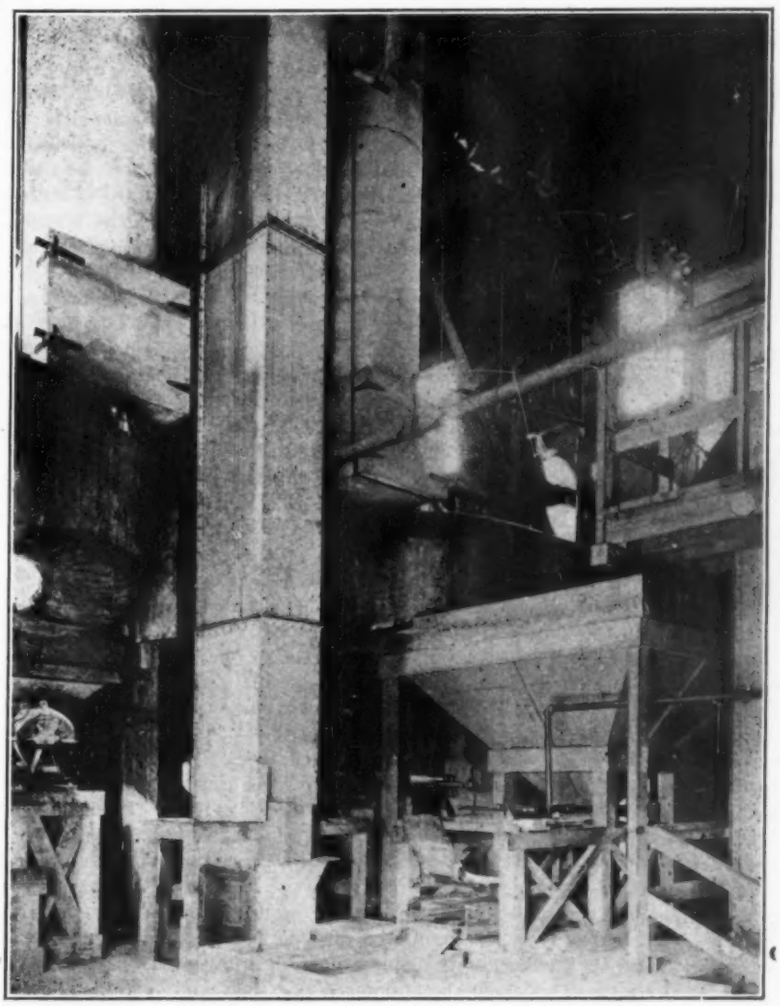


Fig. 3. Interior of Continuous Process Dry House, Old Hickory Powder Plant

Capt. John H. Hall: His Contribution to the Art of Arms

By

THALES L. AMES

WAR DEPARTMENT reports and Congressional records for the first half of the Nineteenth Century refer often to Capt. John H. Hall as an inventor and manufacturer of arms, but no biography or account of his life has been found. Hall's small arms were long known to the Army, as they were manufactured during a period of over thirty years (1819 to 1850), and various organizations were armed with them throughout most of the period.

He first patented his breech-loading arm in 1811, and brought it to the attention of the Ordnance Department in 1813. An order was given him for several for trial and in January, 1817, an order for 100 was given him with a view to arming a company of riflemen with them, by way of experiment these were completed in that year and the officer who received and inspected them made a favorable report. Mr. Hall was then asked to come to Harpers Ferry Armory to assist in the construction of several rifles for the purpose of improving the model. Four were made and favorably reported upon at the Armory. The arms were then submitted to a Board of Officers convened at Greenleaf's Point, D. C., in the winter of 1818-19. The report of this Board was favorable to the new arm. Among other points covered they reported as to "The celerity of loading," "The advantage in favor of the new over the common rifle is as 2 to 1." As to endurance the Board reported:

"The firing of these new arms was continued from time to time until the musket had been discharged 7,061 times, and the rifle 7,186 times, this appearing to the Board, a fatigue at least equal to what these pieces would be exposed to in 14 or 15 campaigns, and probably more than they would be required to undergo."

As a result a contract was made for the manufacture of 1,000 at Harpers Ferry Armory, Mr. Hall to supervise the manufacture as an Assistant Armorer in the employ of the Government. This 1,000 was finished in 1825 and favorably tested by a Board at Fortress Monroe. This Board reported "The Hall Rifle, after having sustained 8,710 discharges, appears in a fit condition for service." "In reporting its opinion of the general utility of Hall's rifle, the staff of the school expresses its perfect conviction of the superiority of this arm over every other kind of small arms now in use." A contract for 1,000 more was made on about the same terms as the first and finished early in 1827.

On April 22, 1828, Hall made a third contract with the United States for 6,000 rifles, including the use of his patented machines for their manufacture, and his personal services in supervising the work. He remained in the employ of the Government at Harpers Ferry Armory until his death, February 26, 1841.

In a report on his work, dated May 2, 1842, the then Chief of Ordnance stated that a total of 25,500 of his rifles had been manufactured and 13,684 of his carbines, and that the latter only was still under manufacture. It was reported at the same time that Hall had been paid for his personal services a total of $17,333.32, and for his inventions, $20,220—$37,553.32. Also, that $149,410.79 had been expended on machinery and tools for the fabrication of his rifles at Harpers Ferry Armory.

The accompanying illustrations show the variety of arms manufactured for military purposes under the Hall patents. They also show quite clearly the general construction by which loading at the breech was accomplished.

The manufacture and use of Hall's arms did not long survive his death. A careful reading of the official reports referring to him indicate that he is entitled to greater fame as an inventor of machines for manufacturing rifles and for his success in using them than for his small arms inventions. In proof of this the following quotations are given. The first is from a letter from the Chief of Ordnance to the Secretary of War, dated January 31, 1827.

"The machinery used in the fabrication of these rifles has been constructed upon a new and improved plan, by which a very important improvement in the fabrication of firearms has been effected. By the aid of this machinery, each of the various separate parts which, when united, forms one arm, are constructed in that perfectly accurate and uniform manner that any one of the parts of one arm will fit exactly the corresponding part of any other arm of similar model. And this perfection is accomplished at a less expense than is occasioned by the use of the ordinary machinery in executing work in the usual and less perfect manner.

"This degree of perfection in the fabrication of small arms has ever been considered an object of the highest importance of all national armories, and has been frequently attempted in the armories of Europe, but hitherto without success. And the attempt has been generally abandoned from the belief that the object was unattainable.

"The machinery constructed for, and used in fabricating Hall's rifles, executes the work with such exactness that the component parts of one hundred rifles made some years past have been joined to other parts made recently without the least difficulty; all the parts fitting as exactly as if each had been separately adjusted to the particular rifle thus formed from the scattered members. This subject was considered of so much importance that a board, consisting of practical armorers and intelligent gentlemen, was appointed to inspect the machinery and the work performed by it. A copy of the instructions given to them and of their report on the subject, is herewith communicated, marked "A," to which I beg leave to refer."

The second is taken from the report of the board just referred to above:

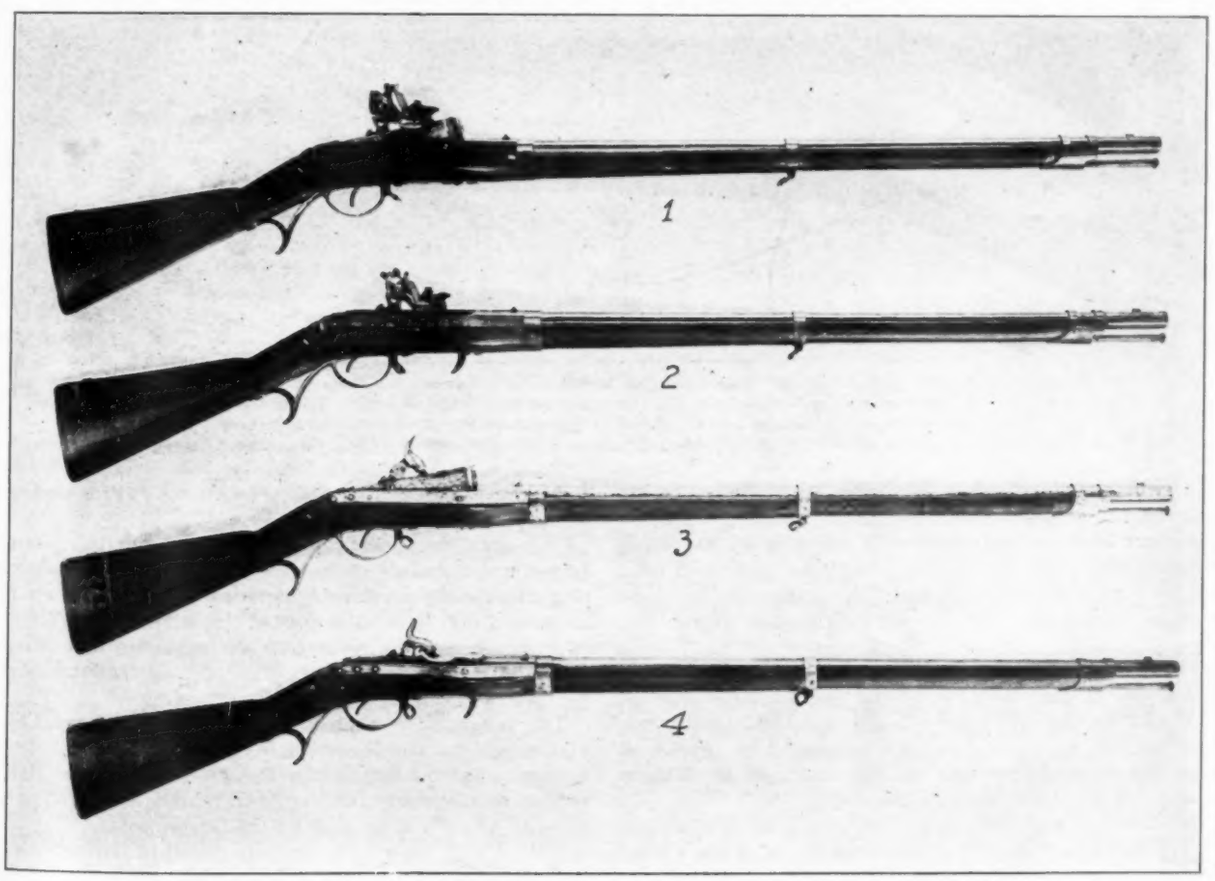
"HARPERS FERRY, VA.,
"January 6, 1827.

"SIR: We, the commissioners appointed by you, in conformity to your instructions of the 2d of December, 1826, convened at Harpers Ferry, in Virginia, on the 11th, and on the following day entered on the duties to be per-

formed by us, viz: an examination of Hall's machinery for making rifles. The result of our examinations and opinions are respectfully submitted in the following report:

"In making this examination our attention was directed, in the first place, for several days, in viewing the operations of the numerous machines which were exhibited to us by the inventor, John H. Hall. Captain Hall has formed and adopted a system in the manufacture of small arms, entirely novel, and which, no doubt, may be attended with the most beneficial results to the country, especially if carried into effect on a large scale. His machines for this purpose are of several distinct classes, and are used for cutting iron and steel and for executing woodwork; all of which are essentially different from each other and differ materially from any other machines we have ever seen in any other establishment.

"Their 'general merits or demerits, when contrasted with the several machines hitherto in general use for the manufacture of small arms,' will, perhaps, be better understood by pointing out the difference of the results produced by them than by any very accurate description of the machines we are able at present to give, although we shall advert to that subject before we close our report. It is well known, we believe, that arms have never yet been made so exactly similar to each other by any other process as to require no marking of the several parts and so that those parts on being changed would suit equally well when applied to every other arm. But the machines we have examined effect this with a certainty and precision we should not have believed till we witnessed the operations. To determine this point and test their uniformity beyond all controversy, we requested Colonel Lee, superintendent of the United States armory at this place, to send to Hall's armory five boxes containing 100 rifles manufactured by him in 1824, and which had been in the arsenal since that period. We then directed two of his workmen to strip off the work from the stocks of the whole 100, and also to take to pieces the several parts of the receivers, so called, and scatter them promiscuously over a large joiner's work bench. One hundred stocks were then brought from Hall's armory which had been just finished, and on which no work or mounting had ever been put. The workmen then commenced putting the work taken from off the stocks brought from the United States arsenal onto the 100 new stocks, the work having been repeatedly mixed and changed by us and the workmen also. All this was done in our presence, and the arms, as fast as they were put together, were handed to us and minutely examined. We were unable to discover any inaccuracy in any of their parts fitting each other, and are fully persuaded that the parts fitted, after all the changes they must have undergone by the workmen, as well as those made designedly by us in the course of two or three days, with as much accuracy and correctness as they did when on the stocks to which they originally belonged. If uniformity, therefore, in the component parts of small arms is an important desideratum (which we presume will not be doubted by any one the least conversant with the subject), it is in our opinion completely accomplished by the plan which Hall has carried into effect. By no other process known to us (and we have seen most, if not all, that are in use in the United States), could arms be made so exactly alike as to interchange and require no marks on the differen-



1. Flexible Smooth-bore Musket. Cal. 54, Manufactured at Harpers Ferry, 1837. Lock open, length of barrel, 30 inches
2. Flint Lock Rifle, Cal. 54, Harpers Ferry, 1831
3. Percussion Smooth Bore Musket, Cal. 54. Harpers Ferry, 1851
4. Percussion Rifle, Cal. 54. Harpers Ferry, 1832

parts, and we very much doubt whether the best workmen that may be selected from any armory, with the aid of the best machines in use elsewhere, could, in a whole life, make a hundred rifles or muskets that would, after being promiscuously mixed together, fit each other with that exact nicety that is to be found in those manufactured by Hall.

* * * * * *

"The 'quality of the work performed.' We have already remarked on this point when speaking of the uniformity of the arms. We would, however, further observe that, in point of accuracy, the quality of the work is greatly superior to anything we have ever seen or expected to see in the manufacture of small arms, and cannot with any degree of propriety be compared with work executed by the usual methods, and it fully demonstrates the practicability of what has been considered almost or totally impossible by those engaged in making arms, viz: of their perfect uniformity.

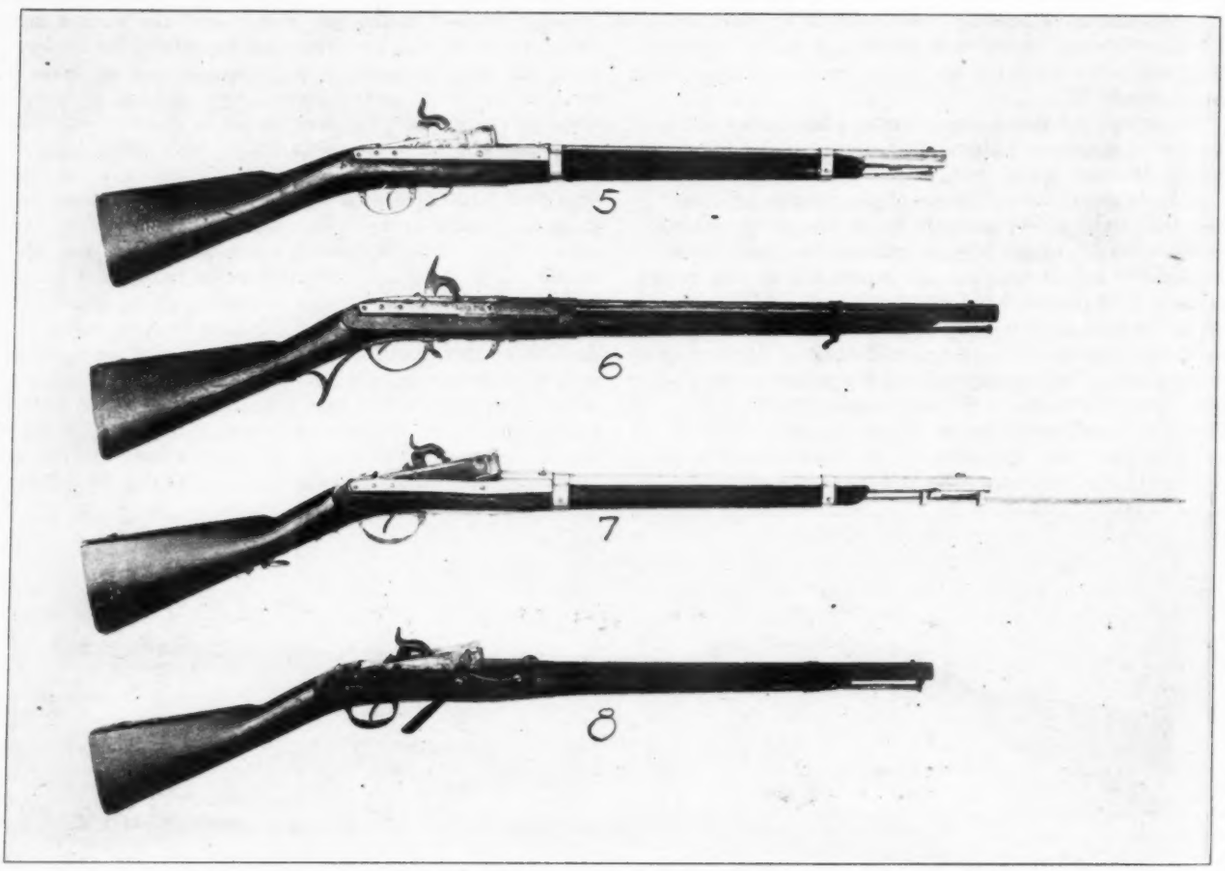
* * * * * *

"It appears equally evident to us that ten thousand arms, in one parcel, may be made by the new machines, and all so accurately that all their parts will suit equally well when interchanged, at a smaller expense than a like number of arms can be made for with the machines now in common use, in the usual less accurate manner."

Mr. Hall, in a petition dated January 5, 1836, addressed to the Senate and House of Representatives of the United States, said:

"Your petitioner has now nearly brought to the highest perfection of which they are susceptible, certain improvements made by him, in the construction of firearms, and in the fabrication of them for the United States service, by means of which, among other objects of magnitude, the desideratum has been effected of the fabrication of small firearms identically, or in such perfection as to admit of the mutual interchanging of all their component parts.

"The yet more difficult object of effecting the fabrication of small arms, with such accuracy as to have all their component parts mutually interchangeable, was considered of so much importance, as to induce great and repeated efforts, by different nations, to effect it, and at great expense, but all their attempts proved ineffectual, and, at length, that object came to be considered as hopeless, and was abandoned as impracticable also.



5. Percussion Smooth Bore Carbine Cal. .32. Brass Trimmings Manufactured at Harper's Ferry, 1842. Length of Barrel 18.5 inches
6. Percussion Rifled Carbine, Cal. .51½. Manufactured by S. North, Middletown, Conn. 1834
7. Percussion B. L. Smooth Bore Carbine, Cal. 54. Rod Bayonet. Patch in Stock, no marks
8. Percussion B. L, Smooth Bore Carbine, Cal. .52, Manufactured by S. North, Middletown, Conn. 1846. Breech Lever on Side

"The great exertions made in Europe, at different periods, as well as those made in this country, to effect such a degree of perfection in manufacturing small firearms, but always unsuccessfully, have fully proved the immense difficulty of effecting it, and the great amounts expended and offered for effecting it show the very high opinions entertained of its value and importance by different nations."

The following is quoted from a letter from the Chief of Ordnance to the Secretary of War, dated May 2, 1842, answering a question as to the extent to which Hall's patents on machinery for identifical fabrication of the parts of small arms, will be used by the Government:

"Mr. Hall's inventions were the result of improvements devised by him from year to year while under the pay of the Government; the materials, workmen, buildings, and machinery being furnished to him by the United States. The improvements as he left them are likely to be retained

in use by the United States, as they have produced a uniformity or identity in the various parts of fire arms that it had long been a desideratum to obtain."

Also from a similar letter dated May 13, 1842:

"To the question whether the principle of the 'identical fabrication' is applied by his machinery to common fire-arms, besides the rifle and carbine, I answer no; but it may be thus applied."

It is interesting to note that the various editions of the "Ordnance Manual" (see editions of 1841 and 1850), state that the Hall Arms should be interchangeable as manufactured and prescribed tests to insure interchangeability that were not applicable to other models.

The date of interchangeable rifle manufacture at Springfield Armory has been set at 1842 when the manufacture of a new model percussion musket was undertaken. Manufacture in quantity on this model did not get well under way until 1844.

The following statement is quoted from the annual report of the Commanding Officer of Harpers Ferry Armory for 1845 with reference to the new model percussion musket under manufacture with new machinery during that year:

"The finish of the musket is very satisfactory; proving that the machines are well constructed, and exhibiting the advantage of this mode of fabrication where all the respective components of the arm are identical one with another, so that the arm complete is made up from parts taken from the general lot, without selection or fitting."

From the above it appears that Mr. Hall first developed the interchangeable manufacture of the rifle in a practical way in the Ordnance Department, U. S. Army, and that he is entitled to great credit. His machinery and methods were doubtless made use of in commercial work and have played their part in the great development of quantity production in the United States. Under the circumstances it is felt that he is entitled to a much higher place among inventors and organizers than has yet been accorded him.

Retubing Antiaircraft Guns—Watervliet Arsenal

Retubing of the 3-inch (15 pdr.) Antiaircraft guns, Model 1917 M1., presented a rather difficult problem in unshrinking, particularly so since it was necessary to remove the threaded breech ring from the jacket without injury to either member.

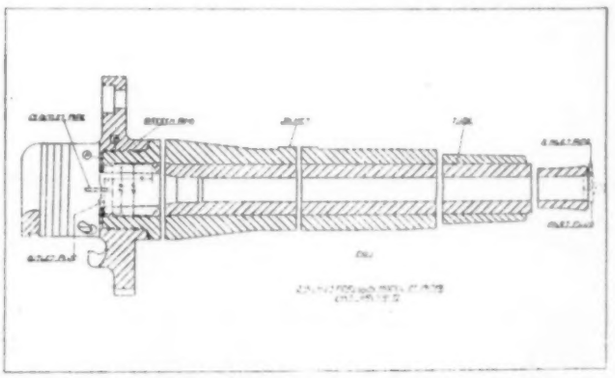
Figure shows the gun as originally constructed. It will be noted that these guns are built up by first assembling the jacket on the tube and shrinking it thereto; a shrinkage of .006-inch on the diameter being used. After the jacket has been shrunk on the tube the rear end is threaded to receive the breech ring which is also assembled with a shrinkage of .006-inch. The thread on the jacket and the breech ring is located by means of templets so that when assembled to proper position contact is obtained between the rear end of the jacket and its seat in the breech ring at point "A," as indicated in figure. Contact is also obtained where the surface forming the rear side of the breech ring threads engages the forward sides of the threads shown on the tube, as indicated at point "B" on figure. It will also be noted that an extention of the breech ring overlaps the tube for a distance of .25-inch, forming a shoulder which assists in preventing the tube from being projected to the rear; this projection making necessary the disassembly of the breech ring in order to retube the gun.

In order to prepare the gun for the unshrinking operation it was decided to bore out the rear end of the tube for a distance of about 6 inches with a contour, as indicated in figure. The shaded portion at the extreme end of the tube was entirely removed. Just forward of where this metal was removed a ring of metal 1 inch in length and .35 inch in thickness was not removed but was threaded for the length of 1 inch in order to provide a water outlet plug; this plug being tapped to receive a 1.5-inch standard pipe. The thickness of the metal in the tube remaining forward of the ring referred to above was .1 inch. The muzzle end of the tube was threaded and provided with an inlet plug which was tapped for a 2-inch standard pipe which was connected to a 2.5-inch fire hose.

After the gun was prepared as outlined above, the rear end was heated in the electric furnace to a temperature of 900 degrees Farenheit after which it was removed from the furnace and secured in a chuck on the shrinkage stand; water being circulated through the tube of the gun from the muzzle to the breech end. Two unsuccessful attempts to unscrew the breech ring with this setup were made. In the first attempt the breech ring was unscrewed about one-third of a turn which had the effect of breaking the longitudinal tension between the bottom or rear face of the jacket seat in the breech ring and the threads. In the second attempt the breech ring was unscrewed another one-third of a turn. At no time during these two attempts did the jacket become sufficiently reduced in diameter by interior cooling to permit unscrewing the breech ring free, and as past experience has shown us that any application of force under these conditions invariably results in galling and scoring both members with the possibility of them even getting frozen so solid that it would be necessary to machine out or off one of the parts, depending, of course, on which member it would be desired to save.

Under these conditions with the possibility of spoiling parts which would cost considerable to reproduce it was decided to apply no great force in our effort to unscrew the breech ring.

The failure to bring about the desired contraction in the diameter of the jacket was attributed to the fact that the joint



Three Inch (15 Pounder) Gun. Model 1917 M 1. (Antiaircraft)

between the jacket and tube acted as an insulating joint to the flow of heat from the jacket through the tube to the cooling medium. There is also the possibility that the tube itself being only .1-inch in thickness at this point contracted, increasing the distance between the tube and the jacket to the point where they were no longer in contact. In order to overcome this difficulty it was decided to completely machine out the shell of the tube which was left remaining in direct contact with the jacket under that portion of the jacket which was threaded. At the same time that this metal was removed the length of the threaded ring was also reduced by about one-half, making it .5 inch in length. After these changes were made the gun was again heated in the electric furnace to a temperature of 900 degrees Farenheit. A third attempt was then made to unscrew the breech ring, which was successful, the breech ring becoming free about twelve seconds after the water was turned on. It was possible to unscrew it free without the application of any great force. The total time required to unscrew the breech ring completely was forty-two seconds.

Development of Automatic Cannon

By

THOMAS M. JERVEY

A QUARTER of a century of development has passed and there is at present no known successful automatic cannon. Why? Must the great nations of the world admit defeat and go on record that the seemingly possible is impossible? My answer is, No. The automatic cannon is just as sure to follow the hand-fed cannon as the machine gun followed the rifle. Why is it then that the automatic cannon is not an accomplished fact? In giving the answer I will first outline the past, present and future needs of automatic cannon.

Fire power has always been one of the most important factors in warfare. History shows that armies were defeated because they did not realize that the enemy had produced a more powerful or faster shooting weapon until it was too late. Thus, when muzzle-loaded guns were used and troops were defeated while trying to reload their weapons, inventors produced breech-loading guns and thereby increased the fire power.

On every hand there were demands for more fire power. Inventors started to work on faster and more powerful guns. Cannon kept pace with the small arms and were never far behind. It is true that many ideas presented for automatic cannon were not considered on account of the cost as compared to that of producing small arms. Nevertheless, the fact that ideas were often presented shows that a need was growing for automatic arms. When the machine gun appeared the automatic cannon soon followed, but the machine gun need seemed to be more pressing and most of the efforts were used in developing the small weapon. Even if a greater need had been seen for the automatic cannon, there was the difficulty of supplying ammunition, and where men could carry small arms ammunition, it took the tractor to solve the transportation of larger caliber ammunition. When the World War came a new power appeared, the airplane. There was soon a demand for armament for it. First, the pistol was used, then the rifle, and later the machine gun. Why then did not the need for automatic cannon appear as soon as the need for the machine gun. From an air standpoint, weight was a prohibitive factor and the development of the automatic cannon trailed behind that of the machine gun. During the first part of the War there did not seem to be a need for an automatic cannon of large caliber. The 75 mm. hand-operated cannon was found to be quite mobile and was soon employed against aircraft. Operation could be accomplished in almost the time of recoil and counter recoil. Therefore, why complicate matters by using automatic cannon?

From an Air Service standpoint the automatic weapon was necessary because the pilot had very little time to operate a hand-fed weapon. The pilot's handicap, however, was quite different from that of his brother on the ground, who could stop his tractor and open fire.

That there was a field for the automatic cannon there can be no doubt. An interesting episode has been related by an officer who visited the upper Argonne after the signing of the Armistice. He stated that it had been found that most of our aircraft was lost in a certain small sector, and upon examining this area he found an emplacement for a small gun and nearby a pile of 37 mm.

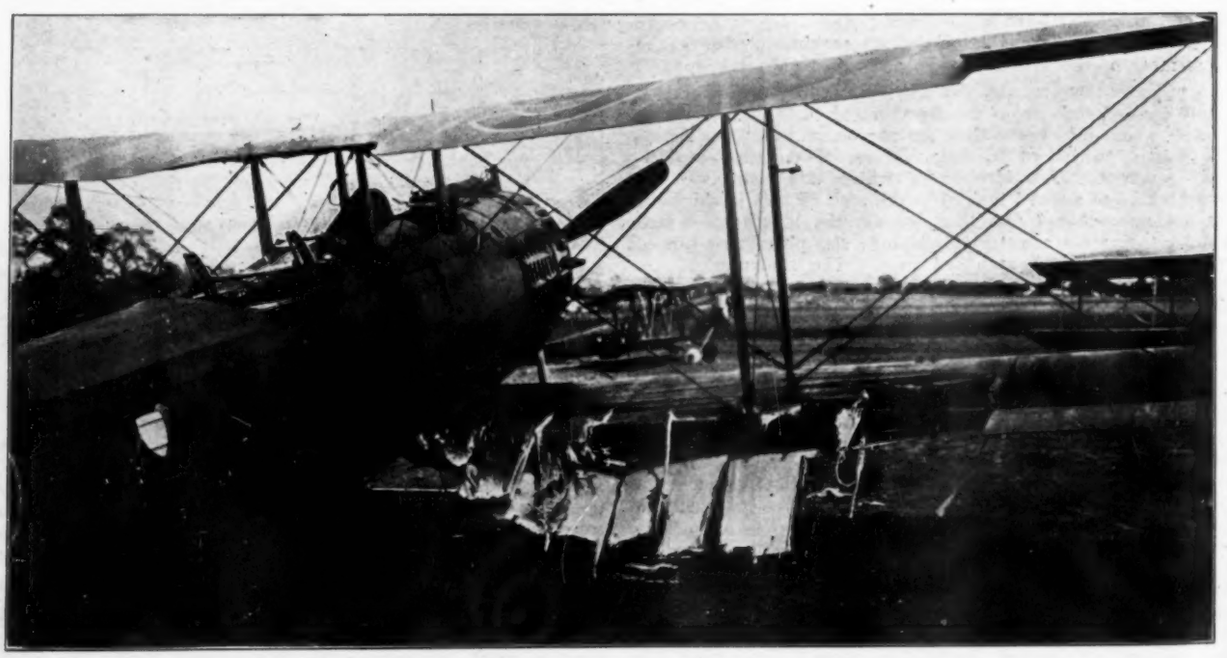


Fig. 1. Effect of 77-mm. High Explosive Fire on Wing of Airplane while in Flight

cartridge cases 15 feet high. This emplacement was near the center of the above sector. The Germans must have seen the need of an automatic cannon as an anti-aircraft weapon and employed it with deadly effect. In selecting the 37 mm. automatic cannon, I presume they figured that as a machine gun is limited to a range of approximately 1,000 yards against aircraft, an airplane could approach the machine gun and retreat in a fraction of a minute and little damage could be inflicted in that time. During every second the range is changed about 40 yards and even when hits are made on the plane the pilot is often protected by armor plate. I suppose they saw their own planes return with several hundred bullet holes in them and no great damage done. They then turned to the 77 mm. gun and even to the 105 mm. gun. After using these guns they probably reasoned thus: The large weapons are too destructive. When hits are made only a small amount of the effect of the explosion is needed and on the other hand a very small error in range will do no damage to the plane. They probably saw this on the planes when they returned full of holes fom the 75 mm. French guns. The Germans then probably said "Why the waste? If a smaller gun could be used and made to shoot faster the problem would be solved."

Figure 1 shows a Sampson plane belonging to the 91st Aero Squadron, just after it had landed from a trip over Metz. The damage was caused by the concussion of a 77 mm. high explosive projectile, which burst just below the plane. Although the damage seems great, the pilot brought the plane back to his own field and made a successful landing.

Figure 2 shows the effect of the .50 caliber machine gun which has a projectile one-half inch in diameter.

This illustration should prove that even the .50 caliber machine gun is limited in destructive power. It is then easy to realize the limitations of the .30 caliber machine gun with its bullet one-sixth the size of the .50 caliber bullet.

Figure 3 shows the effect of 37 mm. fire. Any of these shots would probably put the plane out of commission.

No attempt is being made to prove that the machine gun is doomed. That statement would be absurd. However, as soon as the Army realizes the necessity for the automatic cannon and demands it, then greater efforts will be made to produce it. Why is it then that the American Army has not made more demands for a weapon of this type? I believe one reason is that fair success was obtained by the use of large quantities of ammunition of larger caliber. But on the other hand, could not the results have been much better by the use of a more suitable gun, namely, the 37 mm. automatic?

The question may be asked, What does the future hold for the automatic cannon? I see, even in the near future, all anti-aircraft batteries equipped with automatic 37 mm. guns. Seventy-five mm. guns may even be automatic, especially if in the future the velocity of these guns is made so great that remote control is necessary. When this comes true, another niche for the automatic gun will be made. The battleship will have a 37 mm. automatic gun mounted on its fighting mast. The Air Service will need protection for their airships and also for their superplanes. The need for a gun that will outrange the .30 caliber machine gun and even the .50 caliber machine gun will be absolutely necessary as these airships and planes will be such large targets.

There is even now a large field for automatic cannon, and there is no reason why the commercial inventor should not produce an entirely successful type. The following can be laid down as a fact: The best inventors seldom waste their efforts in trying to produce instruments or weapons that are not in demand. Therefore, unless the Army as a whole talks of the need for an automatic cannon, then they will never have one.

Now that a need for automatic cannon exists, I will briefly outline the development of this type of weapon which started over a quarter of a century ago. The English used a 37 mm. gun in the Boer War. This gun, which was known as the "Pom Pom," was nothing but a large Vickers machine gun. Other inventors then followed. A new machine gun would be given to the world! Almost the next day drawings and models appeared for a supermachine gun of the same type. Thus we had either plans or models of the Maxim, Vickers, Benet Mercie, Hotchkiss, Colt and Lewis. Then, to make it more interesting, a great number of inventors began to combine their ideas and make models of weapons which contained parts from several types. On account of the limited demand for this class of weapon and also because of the limited funds, the ideas of inventors did not receive very much attention until the World War. There was then a rush to make a gun overnight, while its smaller companion, the machine gun, had taken years of study to develop. All of the nations produced their automatic cannon but none was very successful.

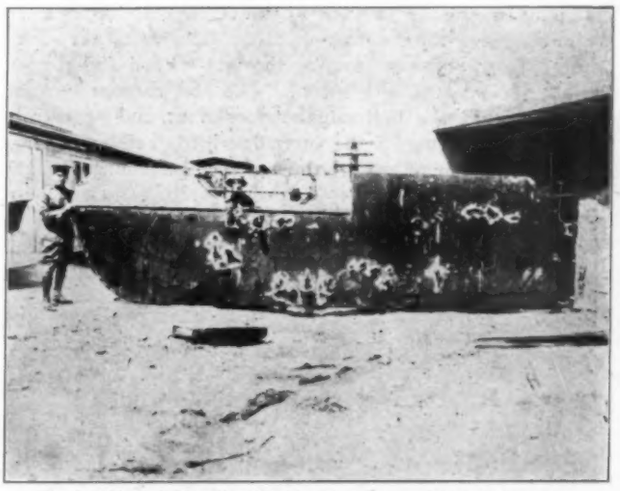


Fig. 2. Effect of .50 caliber Machine Gun Fire on Wing of Airplane

There are several reasons for this failure, of which the most important follow:

First, the ammunition used was generally the same type as that formerly used in hand-fed cannon. Comparing the 37 mm. ammunition with the .30 caliber ammunition as used in machine guns, we find that on the basis of weight, the .30 caliber cartridge case is 1.3 heavier than its projectile, while the 37 mm. cartridge case is .2 as heavy as its projectile. Therefore, on a weight basis the .30 caliber cartridge case is 6.5 stronger than the 37 mm. cartridge case. If, for example, the .30 caliber cartridge is thrown against a wall it can usually be picked up and then inserted in a machine gun and fired, while, on the other hand, a 37 mm. cartridge is usually put out of commission by merely dropping it two or three feet. It therefore appears quite possible that the ammunition for an automatic cannon should be stronger.

Second, the design of machine guns includes the following basic principles:

Either a part of the power produced by the explosion is utilized by causing the expanding gases to move the bolt and feeding parts, or the functioning is accomplished by having a short recoil of barrel which in turn transmits energy into the bolt and feeding parts. Most automatic cannon differ from machine guns in that they have a longer recoil of barrel. Thus, it can be seen that the principle of the machine gun is used only in part. The reason for this is obvious. The cry is always heard for low trunnion reaction and this is best accomplished by long recoil, while long recoil complicates matters by producing a greater variable distance in recoil and this in turn affects the feeding of the cannon. Take, for example, two automatic cannon, the first with a 15″ recoil and the second with a 3″ recoil. The first cannon recoils enough so that the bolt can be opened at end of recoil to allow the feeding of the cartridge into chamber. The variable distance of travel during recoil amounts to at least 3 inches. Thus the cartridge is handled in a different way each time the recoil varies. The second cannon having only 3 inches recoil has a variation of recoil of about one-half inch, and the bolt and feeding mechanism is then moved far enough to the rear to allow feeding. The variation of recoil of the small mass contained in bolt and feeding mechanism is better controlled than in the long recoil of entire mass.

Third, the designers of automatic cannon are always between two fires. On the one side the machine gun designers advise them to keep to the principles of the machine gun, while the hand-fed cannon designers advise that their principle of locking and absorbing recoil be used. As an example, cannon designers in the United States allow only 1 degree 15 minutes angle for the locking surface of breech blocks and require an area of locking surface at least as great as the area of bore of cannon. Machine guns, on the other hand, use angles of locking as great as 15 degrees and an area of locking surface as low as 50 per cent of area of bore. This shows the wide variation in design, especially when one considers that the pressure on a machine gun almost doubles that of a cannon. The reason for the wide difference in design is probably brought about from the fact that large cannon have a series of locking surfaces which, although made to withstand the same strain, often receive greater loads on some parts than on other parts, while the machine gun is usually locked by only one surface. Is it not then possible to concede that the old ideas of design are followed too closely, and should we not now permit the designers to leave present methods of design and at least attempt the new?

In a limited way new ideas of design are actually being undertaken at present. Briefly, they are:

The use of a 37 mm. cannon with its typical sliding breech block, and the addition of an automatic feed for handling the ammunition. A cannon of the same type as above with the exception that feeding is accomplished after both recoil and counter recoil. These two designs are among the first using the so-called cannon principle.

The cannon principle is the use of a breech block which remains in the vicinity of the breech. Examples of this type of breech block are the sliding breech block, the rotating breech block and the hinge breech block. The sliding breech block is being used in both cases, the difference in design being a short recoil of barrel against a long recoil. Thus, the design of both these guns has departed from some of the machine-gun principles, the main one of which is the type of breech block. The difference in the machine-gun principle and the so-called cannon principle is that the machine gun generally has a separating breech block which unlocks by revolving the block or unlocks by the use of cams, and allows the breech block to separate sufficiently to permit the feeding of ammunition beween the breech and breech block. The guns now being designed may not solve the problem, but there is one thing certain, and that is the fact that new lines of development are being tried. The many elements of chance which occur in design have made it desirable to extend efforts in other lines, and a true machine gun of large caliber is being designed. The design of this gun follows the principle of the Browning machine gun which, basically, is the employment of a short recoil of barrel and the further acceleration of a separating breech block, sufficiently to allow the entrance of ammunition to the chamber. The advantage of this type of gun is that the small mass of breech block and feeding parts can be controlled better than a gun which allows the whole mass to recoil. There is also more excess energy and feeding is surer in cases where the entire mass recoils.

A well-known inventor expects to submit an automatic 37 mm. cannon in a very short time and states that he has attained a rate of fire approximately 180 shots a minute. No information is on hand at present on the principles used in the construction of this gun, but many are of the opinion that the problem for a low-velocity cannon is solved.

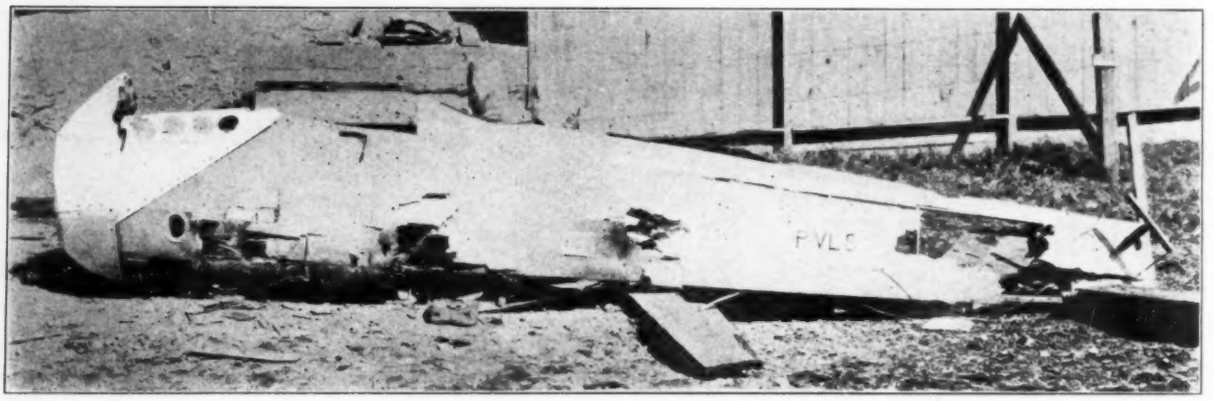


Fig. 3. Effect of 37 mm. Cannon Fire on Fuselage of Airplane

The future development of automatic cannon depends largely on the results obtained in the designs of guns which are now being made. In the event that any of these types are successful, there is no doubt that demands will immediately be made for guns of larger caliber, and it is natural to assume that the most successful 37 mm. gun will be used as a basis for the design of this large weapon. There is no reason why the size of these guns cannot be increased to the largest guns which use fixed ammunition. In the event that no successful design is submitted in the near future, it is probable that efforts will be made to design the following types of guns:

First, a gun constructed in such a manner that it will be necessary for the operator of the gun to pull a lever or turn a crank each time that reloading takes place, in the same way that the Gatling guns were operated.

The second type may be a gun in which a motor operates only the feeding of ammunition and opening and closing of breech block.

The third type may be a gun with several barrels and may be operated by external motor power, such as an electric motor or, in the case of guns of anti-aircraft type, the motor of vehicle. This is the Gatling gun principle with the addition of outside power.

The last two types of guns will probably be quite heavy, as the motors will add considerable weight, and it will be necessary to cool them in some way in order to permit sustained fire.

The United States leads the world in automatic machinery and therefore it is logical to expect an American to produce a successful automatic cannon. If the inventors rest with what they have done, this country will wake up some day to find that we are again unprepared and that the enemy has a weapon which all our resources will not be able to combat.

Machine Guns

By

FREDERICK T. MOORE

MODERN machine guns are of two types in which one or more barrels are used fitted with a mechanical contrivance to secure rapid fire. This is done in two ways, by the movement of a crank handle or a lever which actuates mechanism and continuously reloads and fires the weapon, or by an automatic device using either the recoil of the gun or part of the explosive force of gases of the charge to actuate the mechanism which reloads and fires a succession of cartridges after the operation has been started by firing the first shot.

Colt Machine Gun and Tripod

There are examples of early attempts in various museums throughout the world, some dating back to the fifteenth century. The oldest types of machine gun were known as "Ribaudequins," or "Orgus," that is, organ guns in which a number of barrels were mounted side by side on a frame. They were fired by each barrel being provided with its lock, or by a single lock firing a quick match which ignited the charges of all the barrels in rapid succession. This contrivance possessed little advantage, if any, over the musket fired from the shoulder.

In the days of the Renaissance, armorers produced revolving firearms mounted on light carriages. In view of the absence of machine tools during the early days, however, it was almost impossible to secure the accuracy necessary to have the chambers align with the bore, and the escape of gases between the chambers and end of barrel eroded the metal to such an extent as to make them dangerous to use.

It was not until machine tools had been invented that the more efficient types of machine guns became possible assisted by the invention and introduction of solid drawn copper or brass cases.

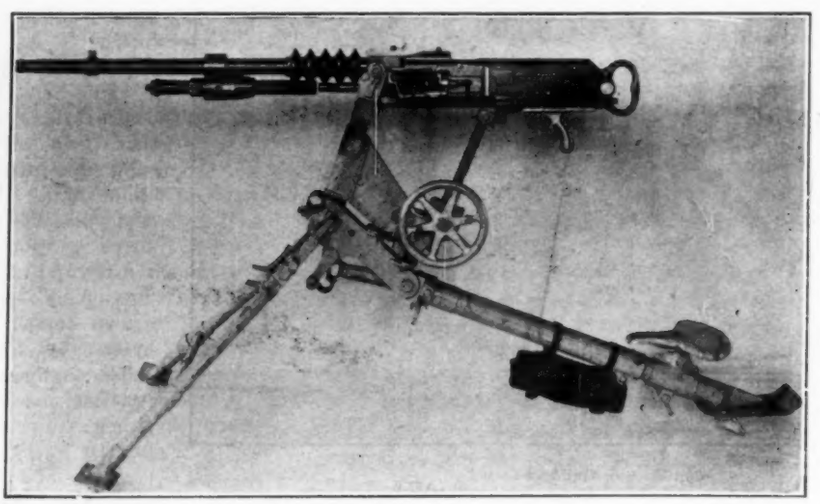
The first really practical machine gun was invented by Dr. Richard Gatling of Chicago, and later of Hartford, in 1862. This gun which was first manufactured by the Colt Company was of the hand-operated type and may be described as a group of six to ten—depending upon caliber—rifle barrels mounted on a central shaft at a fixed distance and mounted on a carriage like that of a field gun. Behind these barrels the loading and firing mechanism was placed. This consisted of a cylinder containing a mechanism which was worked by a crank handle

at the side, cartridges being placed in a feeding apparatus on top of the gun and falling by their weight, one by one, as each shot was fired. On turning the handle, the loading apparatus and the whole system of barrels revolved around the central axis. The cartridges, dropping into the breech, started forward into the barrel which at that moment was in the highest position with respect to the axis. As the barrel passed toward the lowest position the cartridge was pushed home, and, on reaching the lowest point, it was fired; as barrel was up on left side of gun the empty cartridge case was extracted and when the barrel again reached the upper position it was ready to receive another cartridge. Thus when the gun was in action one might say that at a given moment one of its barrels was firing, those on one side being emptied ready for loading, and cartridges were being pushed home in those on the other side.

A few of these guns were used during the Civil War and during the Prussian War, but it was really the English government which demonstrated their usefulness in Africa and India. The Russian government had a large number made at Hartford, and our own government had several hundreds both in the Army and Navy, some of which were used in the War with Spain. Their great weight, however, was a disadvantage and they were replaced during the Spanish War to a large extent by the Colt Automatic Gun.

The Lowell battery-gun, Gardner and Nordenfeldt guns followed the Gatling, and would be placed in the class of hand-operated guns.

Marlin Aircraft Machine Gun Mounted on Colt Tripod



Hotchkiss Machine Gun and Tripod

During the year 1883, Hiram Maxim, an American, born in Maine, invented the machine gun which bears his name; this was the first really successful automatic machine gun. In this gun he used the recoil principle to work the feeding and loading mechanism, cartridges being carried in fabric belts and the barrel cooled by means of a water jacket.

Following the Maxim gun there were a number of automatic machine guns of both recoil and gas-operated types, developed in Europe, namely, Hotchkiss, Schwarzlose, Bergmann, Madsen, Revelli, etc.

The first practical automatic machine gun to be developed in America was manufactured by the Colt's Patent Firearms Mfg. Co. of Hartford, Conn., from the patents of John M. Browning issued in 1892, and was of the gas-operated, air-cooled type. This gun was submitted for test to the Bureau of Ordnance, Navy Department, first in 1896, in competition with several other machine guns of European manufacture, and was selected by the Navy as the gun most suitable for its requirements.

Similar tests were held at Springfield by the Army in 1899, and the Colt Gun was again given the preference, several hundreds of them being supplied to both Army and Navy.

In 1906 the Maxim Gun was adopted by the American government, and a quantity was made by the Colt Company for the U. S. Government.

The Benet-Mercie Gun, which was the invention of Mr. Clarence Benet, an American, and M. Mercie, a Frenchman, was adopted by the American government in 1912; this was a light gas-operated gun. A quantity of these were manufactured by the U. S. Government at Springfield and by the Colt Company of Hartford.

The Lewis Gun was the next automatic machine gun to have sufficient merit to warrant its use by the Government. This gun was first submitted to Government test in 1913, but was not adopted until America went into the War, which brought about the necessity of securing all the machine guns possible, and as quickly as possible. This was a gas-operated gun.

In 1914 the Vickers Gun, which was really the Maxim Gun built over and made lighter, was adopted by the U. S. Government as its standard gun, but the necessity of the war brought about the manufacture of Colts, Vickers, Lewis and Marlin guns. The Marlin was an

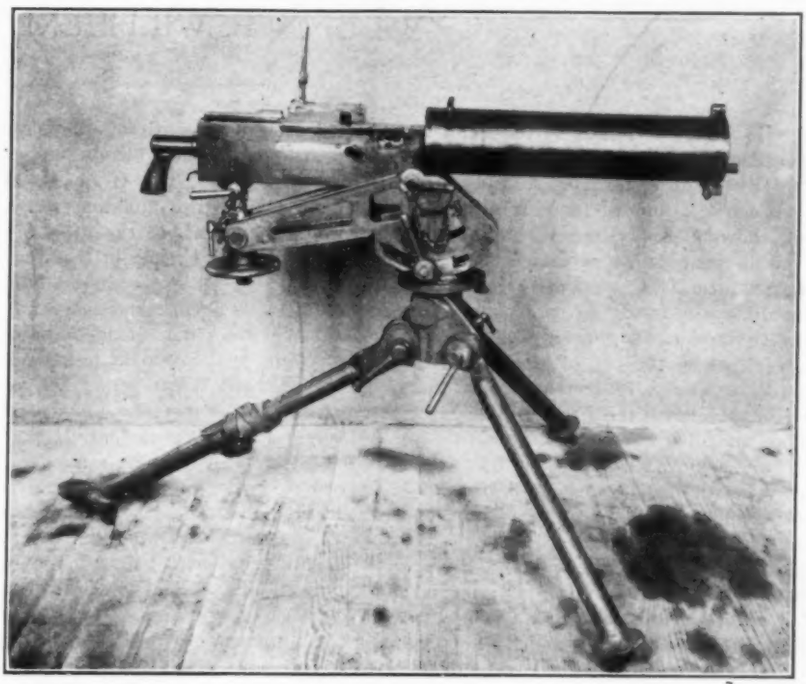
adaptation of the Colt with a horizontally moving piston.

In May, 1917, at a test held in Springfield by the U. S. Government, in which all the above guns were submitted, the Colt Company submitted two new inventions of Mr. J. M. Browning; the first a water-cooled machine gun, recoil-operated, and the second an air-cooled machine rifle, gas-operated. These two guns gave a wonderful demonstration of durability and dependability of action, and were adopted as the standard guns of the U. S. Government land forces.

The American Expeditionary Force, not having a sufficient number of machine guns upon its arrival in France, were supplied with a number of Hotchkiss machine guns by the French government. Some of these guns had been altered to take the old .43 caliber French cartridge which had been made over to take a tracer or incendiary bullet. As our Air Service in France developed, a number of Vickers Guns were converted for aircraft purposes, using this cartridge, inasmuch as we had no .30 caliber ammunition suitable as an incendiary type. A satisfactory type, however, was developed later.

In the early summer of 1918 there came a very urgent request from across the water for a .50 caliber gun having high velocity for barrage work. From the meager information which could then be obtained, it was learned that the British were developing a .50 caliber cartridge for use in rifle and machine gun, and had also converted the Vickers Gun to use a .45 caliber cartridge, a sample gun and cartridge being sent to this country. In view of these facts, the Colt Company and John M. Browning were asked to develop a machine gun for a high velocity .50 caliber cartridge. This gun was completed in September, 1918, and turned over to the Ordnance Department for test. The cartridge for this gun had a velocity of about 2,500 feet and a bullet weighing in the neighborhood of 700 grains.

Just before the signing of the armistice it was discovered that the Germans had developed a .50 caliber cartridge having greater penetration than the American gun but fired from a single shot rifle built on the lines of a Mauser but very much larger. This gun and cartridge showed themselves to be a very formidable combination against the tanks of the Allies and also made it obvious that we must improve our .50 caliber cartridge in the matter of velocity, weight and penetration. This was done, but the accomplishment brought about the necessity of changes in the .50 caliber machine gun to take care of the greatly increased recoil. A new gun was designed and built, and recent tests have given very satisfactory results. This gun is the water-cooled type, and weighs 82 pounds when filled with 16 pints of water. It handles a cartridge having an 805-grain bullet with velocity of approximately 2,500 feet. These bullets are made up in the armor-piercing, incendiary and tracer types. A mount was developed also, weighing about 80 pounds, which showed excellent stability.



Browning Machine Gun

After having completed the water-cooled gun, attention was given to the designing and building of a number of aircraft guns weighing approximately 50 pounds. These guns have been tested out by the Aircraft Armament Division with uniformly excellent results, and are now being mounted in airplanes.

An anti-aircraft and tank gun have also been developed, built on similar lines to that of the aircraft.

It is due to the remarkable genius of John M. Browning, working in collaboration with the Ordnance Department and the Colt Company, that these results have been obtained. It is a fact that whenever Mr. Browning turns his attention to inventing machine guns or automatic arms he has proved himself to have very sound theories, and we believe him to be one of the most prolific inventors of automatic firearms not only of today but of recent times.

Testing Small Arms and Ammunition

PART I

By

GLENN P. WILHELM

THE ranges attained by the small arms of the present day are comparable to the ranges of the field artillery of yesterday. A study of the development of the missile weapons of the infantry, as of all other armament, shows a steady increase in the length of range from the crude weapons of several centuries ago to the present powerful arms.

In the evolution of the rifle it can be shown that, after the introduction of gunpowder, for several centuries the range at which the fire of the individual soldier could be effective was actually decreased over the ranges which had been possible with the English long bow. Upon the introduction of rifled barrels, however, this was no longer true, and guns achieved a real as well as a moral effect.

Anyone who has visited the battlefield of Gettysburg and who is familiar with the power of the modern machine gun is amazed to note that the artillery positions of the two forces in this engagement were within easy machine-gun range of each other. A Browning machine gun of the same caliber as the Springfield rifle, if several batteries of them had been in position along Cemetery Ridge, could have stopped Pickett's charge before it started.

In the Franco-Prussian War the French were so impressed with the range which could be obtained with small arms that they attempted to use the mitrailleuse as a piece of artillery and actually decreased the strength of their field artillery by one-third by replacing them with the new machine guns.

In the Russo-Turkish War the Turks very nearly won the war through their use of the American Peabody-Martini rifle, which often concentrated effective rifle fire upon the Russians at ranges as great as 2,200 yards.

The long-range sniping of the Boers in the Boer War was famous throughout the civilized world.

In spite of the above facts, prior to the World War, no scientific study had been made of long-range small arms firing by any of the powerful armies of the civilized world, although the sights of the Springfield rifle were graduated for 2,700 yards. This was not remarkable, in view of the fact that the doctrine in the United States Army was to the effect that while in emergencies fire of position would be delivered at ranges around 2,000 yards, yet the most important characteristic of the rifle and machine gun was the flatness of trajectory and the striking energy of the bullet up to 1,000 yards.

The barrage firings of the British and French machine gun officers were a revelation to the American Army in France, although it was an American Army officer (Col. John H. Parker, then lieutenant) who pointed the way to the long-range fire of his Gatlings at the Battle of Santiago twenty years earlier. The British in particular were very fond of indirect fire at long ranges and had perfected an elaborate system of fire control. The French, while not as interested in indirect fire as the British, yet were capable of outranging the British weapons on account of the great length of the French Hotchkiss machine gun barrel and their heavy 200-grain, 8 mm. bullet.

The Germans, although not great believers in indirect fire and long-range machine-gun firing, perfected a bullet along the lines of the French which was superior to the French in these respects.

Of course, all this had a natural reaction on the Americans and there was a demand on the part of A. E. F. for ammunition capable of long-range machine-gun firing which would at least be equal to the French. This demand was based upon the popular opinion that 75 per cent of all machine-gun fire in France was indirect fire. It might be stated that, if this were true, 90 per cent of all the machine-gun ammunition which was wasted in France was probably foolishly expended in such kind of firing.

The first fire-control tables that were prepared for the machine gun for ranges beyond 1,000 yards were naturally erroneous, as they were based upon firings held up to 1,000 yards, which was considered to be the all-important range. There were no rifle ranges available in this country or probably in any other country which could be used for the determination of the ballistics of small-arms bullets much beyond 1,000 yards. For this reason, the first tables were computed and forwarded with the first machine guns to France. Firings were then instituted at Borden Brook Reservoir, in Massachusetts, in July, 1918, and the fire-control tables that were obtained as a result of these firings were forwarded to France in September, 1918, to replace the previous erroneous tables. In the meantime, it was very fortunate that the American forces were using Hotchkiss armament. Firings were also carried on by the Ordnance Department on the beach in France at St. Jean des Monts, in September, 1918.

The importance of long-range firing became so self-evident that, although the Armistice was signed in November, 1918, it was decided that the development of long-range ammunition must be continued and ranges were selected at Miami and Daytona, Fla., for the purpose of carrying on the firings. It was at these stations that the present fire-control tables in use by the Army were prepared and it was as a result of the study of the firing data obtained at these stations that the present National Match boat-tail bullet was developed. It may be of interest to note that improved types of cartridge cases and bullets are now being tested by the Infantry and the Cavalry for the purpose of determining their suitability for use in place of the present service ammunition.

It was impractical to maintain ranges at points so far away as Florida, even though the ideal weather conditions which generally exist at certain periods of the year in those regions made this very desirable. A small-arms firing range was therefore started at Aberdeen Proving Ground, Maryland, a discussion of this range being given in the March-April, 1921, issue of ARMY ORDNANCE in the article by Maj. Lee O. Wright on "The Aberdeen Small Arms Firing

Range." At the time Major Wright wrote his article the range was under construction. Since that date it has been completed along the lines originally intended and has been functioning for a period of over a year. The tests being conducted on this range are of a great deal of interest and the remainder of this article will be mainly devoted to the operation of the range in firing tests at the present time and the plans for improvement which are expected to be put in operation in the future.

The plan of this range was made up as the result of the study of the characteristics of the Florida ranges. As may be imagined, it is very difficult to determine the impact of small-arms bullets at long ranges, as there is not the facility for observation as is true of artillery shells.

The range proper consists of an open area of water, called the "water impact area," upon the surface of which the splashes of the bullets are observed from three towers. The area about the towers is cross-sectioned off by rows of stakes. The usable portion of the water area is about 100 yards wide and 600 yards long, although shots can be ranged in upon a far larger area. The range from the firing point is varied by having the firing point movable upon a narrow gauge railroad which extends back about 6,000 yards from the impact basin.

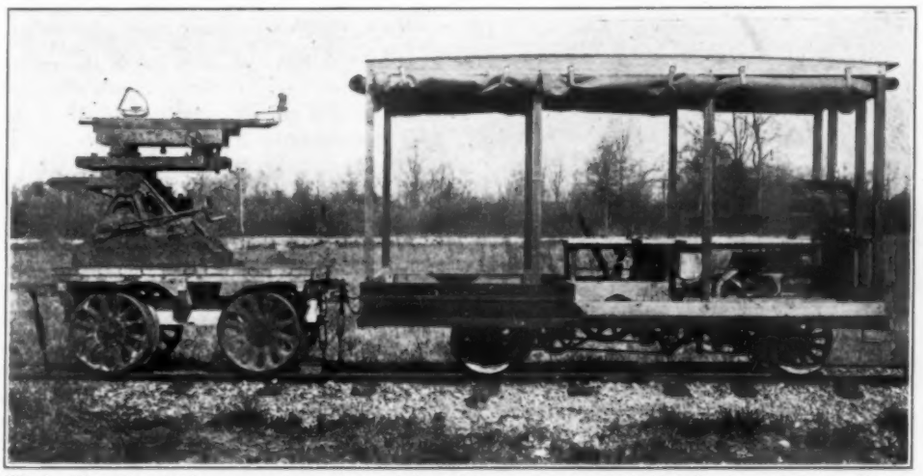


Fig. 1. Movable point for changes in range, consisting of narrow gauge car with Ford Engine and Tractor Mount with machine rest supporting caliber .50 Mann barrel in firing position

An auxiliary range, consisting of the usual type of vertical targets, has been constructed parallel to the narrow gauge railroad at the end of the range farthest from the pool. All firings up to about 1,200 yards are carried on with these vertical targets. In fact, the major portion of these tests is held on this part of the small-arms range, as the buildings which house the instruments and apparatus, including the usual range facilities, are at this location.

The method of carrying on a typical test at the present time is as follows:

Suppose, for instance, a new type of small-arms bullet is being tested to determine its ballistics. A program is prepared in advance, drawing up specifications and the way in which the test will be carried out. This program includes the firing of the ammunition for velocity and pressure in the usual way. It also calls for the determination of the trajectory at all ranges by means of measuring successive elevations against range. In the case of both the rifle and the machine gun, the dispersion of the ammunition at various ranges must also be measured, as well as the effect of erosion of the barrel on the dispersion. In addition, the program usually includes the determination of the time of flight of the bullet for the purpose of obtaining remaining velocities, and what is more important, striking energy. With the above data, it is possible to obtain all other ballistic characteristics of the bullet, such as the angle of fall, although the latter may be measured.

The detailed steps of carrying out the above provisions are along the following lines:

Pressure.—This is measured by the use of the pressure gun, involving the use of copper cylinders which are compressed by the action of a plunger when the cartridge is fired, the calibration of the change in the length of the copper being an indication of the pressure.

Velocity.—This is measured by either one of two methods:

a. The Boulengé Chronograph. This is an electrical device which, by means of an interruption in its circuit by reason of the bullet cutting two wires in the electric circuit at a certain distance apart, allows the dropping of two weights which actuate a mechanism in such a way that the distance one of the weights drops during the time of travel of the bullet is registered, and thus the velocity of the bullet is obtained.

b. The Aberdeen Chronograph. This consists of a drum rotating by means of an electric motor at a constant known speed, upon which by means of a waxed paper strip the distance between the time of discharge of two electric sparks is obtained, the electric sparks being brought about by the making of an electric circuit by the bullet in passing through two sets of leadfoil screens at a known interval apart. The Aberdeen chronograph is one of the developments brought about by the war and was designed jointly by the Ordnance Department and the Bureau of Standards.

Elevations.—The elevations at a given range can be obtained in a variety of ways, the simplest of which consists of the use of the Mann rest and a precision clinometer. The Mann rest is simply a V-shaped cast-iron block machined to a constant angle and upon which a very heavy rifle barrel with concentric rings recoils freely. All the surfaces being machined, it is possible to measure directly the elevation at which the bullet is fired. A correction must be made for the impact of the bullet. This correction becomes zero on the vertical paper target if it is at the same level as the barrel. When firing on the water impact area, this correction must always be made for the angle of site: *i. e.*, the angle between the horizontal plane through the gun and the line from the gun to the point of impact on the surface of the water.

When using the service rifle in the Frankford type of machine rest, it is necessary to make a special clinometer seat which fits in the receiver and on the fixed sight base of the rifle and upon which the clinometer is placed.

The elevation can also be obtained by the use of a transit which measures the vertical angle that the bullet passes through a paper screen at 1,000 inches from the gun. Since it is sometimes desirable, if not necessary, to measure not only the elevation at which the bullet leaves the gun, but also the jump of the center line of the bore of the gun at the moment of discharge, this is accomplished by firing through a thin paper screen at 1,000 inches and by the use of two transits, one transit being adjusted on the fixed base of the Frankford machine rest in such a way that the line of sight of the transit is at the same height as the center line of bore of the rifle, while the other transit is in

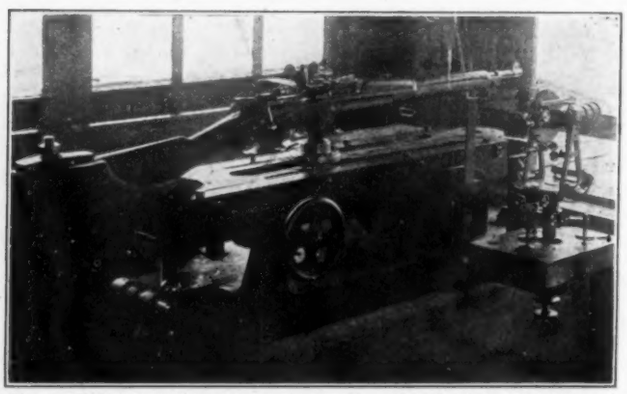


Fig. 2. Rifle in machine rest showing one transit on fixed base to right and another on movable base at left in measuring elevation, deflections and jump

a similar position on the movable base of the Frankford machine rest. The procedure is as follows:

A bore sight target is set up at one side of the paper screen and the rifle bore-sighted on the target. The cross hair of the telescope of the transit on the movable base is then set on the bore sight target and all readings adjusted to zero. The other transit is simply adjusted so that when the line of sight through the telescope is horizontal, the reading is zero. When the rifle is fired the jump, both vertical and horizontal, is obtained directly by sighting the cross hairs of the transit which is on the movable base on the hole in the screen and reading the vertical and horizontal angle. Of course, this transit moves with the gun and when the readings of the vertical and horizontal scales are zero, the cross hair on the screen and the center line of bore on the screen coincide, except for the drop of the bullet. On the other hand, the other transit is set with the line of the telescope on the shot hole and, since it is on the fixed base, the reading of the vertical scale gives directly the angle of the line of departure of the bullet. This transit will also give the lateral deflection of the bullet if the horizontal scale has been zeroed on the zero line of the center line of bore, even though there is an apparent parallax.

By the above means, groups of ten shots each may be fired very rapidly and the angle of jump and the elevation and direction at which shots leave the gun measured without any other personnel except the operator of the machine rests and the transits. Of course, to determine the combined elevation and range, the distance the impact at the target at which the firing is being carried on, is above or below a horizontal line through the gun must be used as a correction for the original angle measured. That is, if the bullet leaves at an angle of 53 minutes above the horizontal and at 1,000 yards its distance at the target is 30 inches above the horizontal line from the gun to the target, then the true angle for the bullet is 50 minutes, as the 30 inches corresponds to 3 minutes, which must be subtracted from the original elevation. If the bullet landed on the horizontal line, no correction would be made.

In measuring the dispersion of the ammunition, this is done either in the rifle held in the machine rest, in the Mann barrels with the V block or in the Browning machine gun mounted on a stable base. This dispersion, when using the rifle either in the machine rest or the heavy barrel in the Mann rest, is carried out in the usual way by firing groups of 10 shots each at various ranges and measuring the targets for the following factors:

Mean and extreme vertical deviation.
Mean and extreme horizontal deviation.
Mean radius.

At ranges less than 600 yards the rapidity of the firing is facilitated by substituting a roll of paper in place of the usual vertical target, so that as soon as one shot group is fired the paper is slightly rolled up, leaving a clean paper for the next succeeding shot group. This greatly improves the speed of firing and minimizes mistakes, as a permanent record is always obtained which can be referred to at any time and conveniently measured. No pasting up of bullet holes and other time-consuming and laborious details are necessary, except at the longer ranges.

At ranges beyond about 1,000 yards, the dispersion is usually obtained on the water impact area, the variation of the location of the splash of succeeding bullets being noted on the surface of the cross-section area.

In the case of the machine gun, the same method applies as for the rifle, except that such measurements usually consist of automatic bursts of fire in place of a successive number of individual shots. When firing the machine gun automatically on the water impact area, it is only possible to observe the limits of the dispersion—that is, the shortest and the longest shots, and the two widest shots.

Erosion.—Erosion tests in both the rifle and machine gun are carried on along the following lines:

In the machine gun automatic bursts of 50 rounds each are fired at a range of 1,000 inches into a paper screen which can be rapidly shifted by unwinding the roll of paper between each burst, thus giving a clean sheet for each shot group. A rate of fire of 200 rounds a minute is maintained and the water jacket is kept continually full of water by means of a pump or by elevating the water box so that the water will run through the water jacket by gravity.

When the average maximum diameter of the shot group of any ten consecutive bursts exceeds by 300 per cent the maximum diameter of the first ten bursts the test is discontinued for that gun barrel and type of ammunition. The test is also discontinued if in any three consecutive bursts two or more keyholes appear, *i. e.*, bullets passing through the screen sideways.

The test fired in this way takes usually about an hour as, at a rate of fire of 200 shots a minute, it will require 50 minutes to fire 10,000 rounds, which is about the average length of barrel life. The firing is not stopped for any measurements, the only measurements being taken are at the beginning of the test and consist of velocity, pressure and star-gauge measurements. These measurements are repeated at the end of the test.

(To be continued)

Thompson Gun, Military Model, equipped with Bipod and Type C (100 cartridge capacity) Drum Magazine

The Thompson Gun, Model 1923

The Thompson Submachine Gun which was originally developed to fire the caliber .45 pistol ball service cartridge, has now been redesigned to fire rifle ammunition.

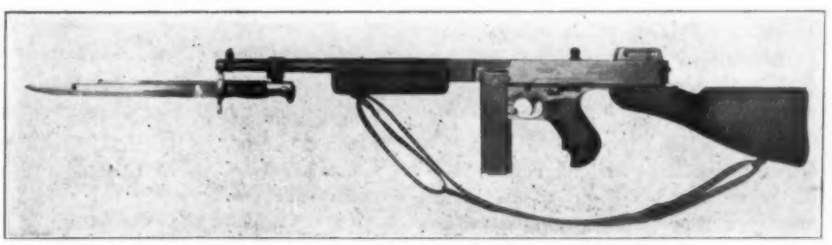
It has been developed that the original mechanism will safely lock and withstand chamber pressures of rifle cartridges up to and including 40,000 pounds per square inch.

A new military rifle cartridge, caliber .45, with a chamber pressure of about 20,000 pounds per square inch with a weight of bullet of 250 grains has given very satisfactory results at ranges up to and including 650 yards.

By virtue of using a nominal velocity and a bullet of heavy shocking power many highly desirable advantages are secured in comparison with heavier type machine rifles firing high pressure cartridges. Such advantages include (a) substantial reduction in weight, (b) reduced recoil, (c) prolonged continuous firing without overheating and (d) super-magazine capacity.

By reason of firing a nominal pressure cartridge up to and including the above indicated range, it is possible for the gun to fire more accurately full-automatically than is possible using high-pressure cartridges where great recoil heavier type machine rifles to pull, often shooting them off the target when fired in that manner. The advantage of reduced recoil also enagles a more rapid rate of semi-automatic firing. In addition, there is no necessity to fire at a slower rate or because of overheating the barrel. The reduced recoil permits the firing of an unlimited number of rounds without bruising or shocking the body.

The present models of the Thompson Gun have been chambered to fire various types of modern rifle ammunition with chamber pressure under 40,000 pounds.



Thompson Gun, Military Model

Specifications of the Military Model are, weight 12 pounds, length 36 inches, length of barrel 14½ inches, rate of fire, semi-automatically 125 shots per minute, full-automatically 400 shots per minute, caliber 9 mm., caliber .35, caliber .45 ammunition.

The characteristics of the Military Model (equipped with bipod and Type C—100 cartridge capacity—Drum Magazine) are weight 13 pounds, length 36 inches, extra heavy 14½-inch finned barrel, rate of fire, semi-automatically 125 shots per minute; full-automatically 400 shots per minute; caliber 9 mm., caliber .35, caliber .45 ammunition.

Letters to the Editor

An Open Forum for the Discussion of All Phases of Industrial Preparedness

An Opportunity for Practical Cooperation

DEPARTMENT OF MILITARY SCILNCE AND TACTICS
UNIVERSITY OF MICHIGAN

ANN ARBOR, MICH.,
May 1, 1923.

The Editor, ARMY ORDNANCE:

I have for some time been considering a method whereby the members of the Army Ordnance Association may further promote the purposes for which the association was formed by rendering certain assistance of great importance to members of the Ordnance Units of the Reserve Officers' Training Corps.

A large majority of these men are earning part, if not all, of their college expenses, and are dependent upon summer employment for the money with which to cont'nue in school. During the spring most college men arrange for their summer positions, and they are required to start work immediately after school closes. The men who go to the Advanced Camp, which closes July 25th, find it extremely difficult to secure suitable employment during the remainder of the summer. Here at the University of Michigan a number of men have, for this reason, been unable to enter the advanced course and complete the work required for a commission.

It occurred to me that many of the members of the Army Ordnance Association are in a position to offer summer work to those students who desire it, and after talking it over with men who are now in the advanced course, I am sure it would increase the strength of the Ordnance unit. I would suggest trying to arrange first for those men who are going to the Advanced Camp. Later, I hope it would be practicable to extend the arrangements so as to take care of the Ordnance men during the other summers.

Advantages

1. It would increase the enrollment by interesting men who are not now able to take the work.

2. The fact that members of the Association are sufficiently interested to put across such an arrangement would increase the morale of the men and make them feel that they are getting into something which is alive and active.

3. By gaining experience in work along the general lines of his college course, a man will become more expert in his field and therefore of more value to the Ordnance Department.

4. A few very desirable men who are taking special courses have difficulty in completing enough subjects to get the required number of Ordnance credits. These men could be assigned to those positions for which Ordnance credit could be given. In this way a few men could be commissioned who would otherwise be lost.

5. Members who employ students during the summer would have an excellent opportunity to judge of the qualifications of some of the most desirable students at the various colleges, with a view to employing them after graduation.

6. It is difficult for inactive members of any organization to keep up their interest. This will give an opportunity for many men to push the work along who cannot otherwise actively participate in the work of the Association.

Suggestions

There will be no time this year to make arrangements before the men get to camp. I would therefore like to ask all members of the association who can employ even one student for from six to eight weeks to write direct to the Commanding Officer, Ordnance R. O. T. C. Camp, Aberdeen Proving Ground, Md., attention of Director of Military Training. State the kind of work you have, the pay offered, and the kind of man you want. We will have undergraduate chemical, mechanical, electrical, and aeronautical engineers, as well as industrial engineers and students of business administration. I will be there this year and will do my best to handle things satisfactorily at that end.

Next year it may seem desirable to make arrangements in advance, possibly through the Ordnance district chiefs. But there is no time for that this year. The success of the matter this year rests upon the action each member takes immediately upon receipt of the May-June issue. The students here are expecting the members of the association to cooperate. Every man who is placed will help the member, the association, the Ordnance Department, and the unit at the institution from which the man comes. Will you help put it over?

Very sincerely,

JOHN A. BROOKS, JR.,
Major, Ord. Dept., U. S. A.

Colonel Alten S. Miller Discusses Shell Design

THE BARTLETT HAYWARD COMPANY
FOUNDERS AND ENGINEERS

OFFICE OF THE VICE-PRESIDENT

Baltimore, April 13, 1923.

The Editor, ARMY ORDNANCE:

I have read with great interest Mr. Adelman's paper on "Carton Loading" in the last issue of ARMY ORDNANCE.

I am hardly familiar enough with loading methods to express an opinion on the subject of carton loading, but, in view of the fact that the design of the shell seems to be involved in the method of loading, the subject is one of very great interest to me.

I note that Mr. Adelman leans toward a shell that is nosed in. I have been hoping that in getting out the new design of shell, which I take will be necessary, this design could be worked out with a straight cylinder having a plug in the end and a false cap. Of course, the cylinder would run back only as far as the band, as I take it that the shell would be boat-tailed behind the band.

I have assumed that a complete set of new designs would be developed, in view of the fact that the Germans outranged us in every caliber, and under the circumstances it would seem advisable to design shells that are at least equal to the German shells, if not better. Mr. Adelman suggests that it is possible to get greater capacity in shells that are nosed in than is the case with the shell made in two parts. This may be the case, but I wonder whether sufficient designs have been studied to demonstrate the fact beyond

question. It would seem to me that, with the false cap and a comparatively light plug in the end of the shell, it would be possible to design a shell of the same efficiency as is the case when the shell is nosed in.

Assuming that it is not possible to secure the same efficiency with the shell that is not nosed in, this would not be a fatal defect in the eyes of many authorities on this subject, as the English particularly worked with low capacity shells and the difference in capacity as indicated in shells "D" and "E," illustrated on page 263 of Mr. Adelman's article, is not very great.

There are many advantages from the point of view of manufacture, which means lowering of first cost, in using the straight shell that is not nosed in, that it would seem advisable to use every effort to secure a satisfactory design. It is useless to argue that shells cannot be satisfactorily nosed in and produced in any quantities, but the operations of nosing and machining the shells after they are nosed are slow and expensive, and, if it is possible to avoid them, it should be done. It is true, as Mr. Adelman suggests, that it would be desirable to anneal the shell where it is threaded, but, if the weight ahead of the bourrelet is sufficiently reduced, this should not be a disadvantage. Malleable iron heads have been used on 4.7" and 6" shrapnel and I have never heard of any complaint of the strength of this material.

The best projectile is none too good and when the cost of firing the projectile is taken into consideration, which cost would include the proportion of the transportation and maintenance of the Army and all expenses connected therewith, the cost of the shell itself is a very small part of the total, and no expense should be spared to make it as perfect as possible. On the other hand, if the manufacture can be simplified without affecting the quality of the shells, the cost will be reduced and the production per man increased, which is very important in time of war.

Sincerely yours,

ALTEN S. MILLER.

Book Reviews

"Post-War Ordnance." By Major LeRoy Hodges, O. R. C., State Ordnance Officer, Virginia National Guard; 113 pages, many illustrations. Price, $1.50 in paper, $2 in cloth. May be ordered through the Secretary, Army Ordnance Association.

Army Ordnance welcomes this excellent publication for two reasons. It represents the first attempt on the part of anyone to bring together in one book a record of the progress made in the United States in the development of ordnance for the Army since the World War. In the second place, this work has been done by a member of the National Guard who is also an officer of the Reserve Corps, thus emphasizing the growth of the "one army" idea.

The chapters of the book are as follows: Ordnance Department; Guns and Ammunition; Explosives and Fuzes; Coast Defense Artillery; Army and Corps Artillery; Divisional and Pack Artillery; Anti-Aircraft Artillery; Super-Machine Guns; Aircraft Guns; Small Arms and Pyrotechnics; Automotive Equipment.

Major Hodges has produced an extremely readable and interesting account of the post war ordnance development in terms understandable to the layman. His book will be of great value to officers and others who desire to keep their ordnance knowledge abreast of the times. It is a most welcome addition to ordnance literature.

R. H. S.

"Operations of the 29th Division." Compiled by Major W. S. Bowen, C. A. C.; The Coast Artillery Journal, Fort Monroe, Va., 1923; 6 x 9¼, 410 pages. Price $1.25.

This volume is a source book of information concerning the operations of the 29th Division (U. S.), east of the Meuse River, October 8 to 30, 1918. It will be a splendid reference to the student of military history.

Containing, as it does, original messages and reports made during and immediately after the operations referred to, it affords firsthand information and gives an impression of what modern battlefield conditions are that cannot be obtained from a book written in the calm of the study.

In addition to the reports of all the units, from that of the division commander down to and including those of all the platoon commanders, this book contains the messages sent from and received at Division Headquarters; Field Orders, First Army; Field Order No. 18, 29th Division; Field Orders, 18th Division (French); Field Orders Nos. 19-25, 2 .h Division; and a specially prepared 1/20,000 French Plan Directeur which embraces the front occupied by the 29th Division.

R. H. S.

Dimensional Analysis: By P. W. Bridgman, Professor of Physics in Harvard University. Yale University Press, New Haven. 112 pages.

Here is an excellent volume by Professor Bridgman on the much discussed, yet rarely understood, principles of dimensional analysis. Needless to say, because of the importance of these principles in the general field of technical physics the volume is both timely and convenient. The author defines the purpose of the work as an attempt at a "systematic exposition of the principles underlying the method of dimension analysis" with illustrated examples "especially chosen to emphasize the points concerning which there is the most common misunderstanding, such as the nature of a dimensional formula, the proper number of fundamental units, and the nature of dimensional constants."

The treatment of the subject is divided into the following chapters:

1. Introductory.
2. Dimensional formulas.
3. On the use of dimensional formulas.
4. The II Theorem.
5. Dimensional constants and the number of fundamental units.
6. Examples illustrative of dimensional analysis.
7. Applications of dimensional analysis to model experiments; Other engineering applications.
8. Applications to theoretical physics.

There is also a section of the book devoted to practice problems. The book is a handy reference and an authentic guide to those of the engineering professions—especially to Ordnance technicians—whose activities embrace dimensional calculations.

L. A. C.

Professional Notes

ARTILLERY DIVISION

Stability and Road Clearance of Divisional Artillery.—Four pilot carriages, designed and built by the Ordnance Department to meet the requirements of the Caliber Board, have been under test by the Field Artillery at Fort Bragg, N. C. Two of these carriages are Model 1920 (split trail) and mount either a 75-mm. gun or 105-mm. howitzer. The other two are box trail carriages, Model 1921; one for a 75-mm. gun and the other for a 105-mm. howitzer. The last two carriages are not alike and the gun and howitzer will not interchange as on the Model 1920 carriage.

These pilot carriages have been found to have too little road

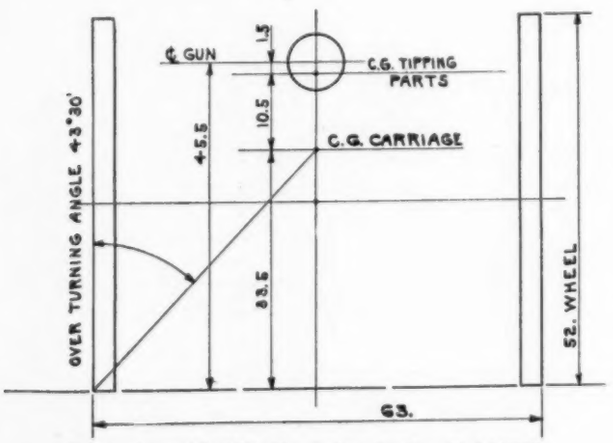


Fig. 1. Lateral Stability 75 mm. Gun Carriage, Model 1923E

clearance when traveling with the limber and the tendency to overturn sideways on a sloping terrain was thought to be greater than former designs. These alleged defects were considered due to 48-inch wheels instead of 56-inch wheels as used on the 3-inch gun material, Model 1902. The smaller wheel was used to get increased firing stability and to reduce the weight of the wheels, especially those with rubber tires.

Tests were made at Aberdeen to determine by trial the over-turning angle of several carriages and a 75-mm. Gun Caisson, Model 1918, loaded with shrapnel. The height of the center of gravity was then located graphically on the drawing of the carriage. The results are as follows:

Carriage	Overturning angle	C. G. from ground
3-inch Gun, M. 1902	44° 16′	32.3 inches
75-mm. Gun, M. 1897MI	42° 49′	33.75 inches
3-inch Gun, M. 1916	43° 6′	
75-mm. Gun, M. 1920E	43° 23′	32.45 inches
105-mm. How., M. 1920E	43° 53′	
75-mm. Gun Caisson	42° 27′	

A study was made to find the stability when firing and the ground clearance when limbered. The results have been tabulated as follows:

FIRING STABILITY OF DIVISIONAL ARTILLERY

Carriage	M. V.	Pull	Angle	Weight
3-inch, M. 1902	1,700	3,990	0°	2,520
75-mm. M. 1897MI	1,750	5,250	7°	2,657
75-mm. M. 1916	1,700	5,030	0°	3,045
75-mm. M. 1917	1,750	3,600	0°	2,945
75-mm. M. 1920E	2,175	6,900	12°	3,670
75-mm. M. 1921E	2,175	10,000	15°	2,733
75-mm. M. 1923E	2,175	8,550	7½°	3,200

ROAD CLEARANCE OF DIVISIONAL ARTILLERY

Carriage	Gun in Battery	Gun Traveling	Road Clearance at Spade	Road Clearance at Axle or Shield	Diameter of Wheels
3-inch Gun, M. 1902	40.875	40.875	20.25	21.5	56.
75-mm. Gun, M. 1897MI	40.4	39.25	14.	13.5	52.5
75-mm. Gun, M. 1916	41.625	41.625	25.5	17.75	56.
75-mm. Gun, M. 1917	36.86	35.5	16.75	19.	56.
75-mm. Gun, M. 1920E	39.	43.25	16.	13.5	48.
75-mm. Gun, M. 1921E	39.24	43.5	14.	14.75	48.
75-mm. Gun, M. 1923E	41.5	45.4	20.	18.	52.
105-mm. How., M. 1920E	39.	42.25	16.	13.5	48.
105-mm. How., M. 1921E	38.	40.	13.5	13.	48.

Note.—All dimensions are inches.

The comparative lateral stability of the new 75-mm. Gun Carriage, M. 1923E, is shown in Fig. 1. Note that the wheels are 52-inch diameter, which is a mean between the 56 and 48-inch diameter previously used. The track of the vehicle is the same as the other models.

Fig. 2 shows the forces on the 75-mm. Gun Carriage, M. 1923E.

Medium Tank, Model 1921.—The Medium Tank, Model 1921, at Camp Meade has been temporarily withdrawn from test on account of failure of the engine crankshaft. Pending the repair of this engine and in order to permit the uninterrupted test of this experimental tank, a Liberty engine is being installed.

155-mm. Gun, 8-inch Howitzer Motor Carriage, Model 1921.—The No. 2 pilot 155-mm. Gun, 8-inch Howitzer Motor Carriage, Model 1921, under test at the Aberdeen Proving Ground, has completed some 500 miles of test running under conditions selected to determine the operating characteristics of the carriage and to develop weaknesses or defective material. Generally speaking, the performance of this motor carriage has

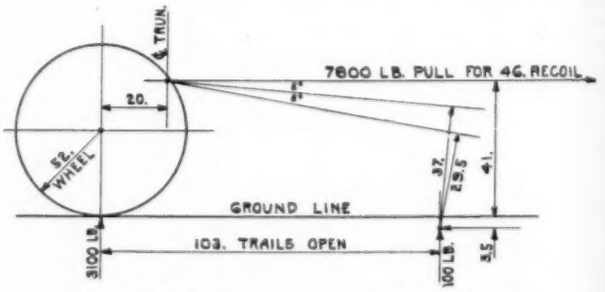


Fig. 2. Firing Stability 75 mm. Gun Carrirge, Model 1923E

been very creditable and the design appears to be a promising one.

The carriage is of the typical caterpillar construction, representing an effort to produce a light weight carriage for the gunpower carried, and having high engine power to insure satisfactory operation over all kinds of ground conditions.

Compared with earlier designs for Army artillery, this carriage is a great advance in the art of motor carriage construction.

The test of this and other carriages of the track-laying type indicate the necessity for certain modifications and changes in the track and track roller mounting, to insure better operation and control under all conditions.

The No. 2 motor carriage will, therefore, be sent to Rock Island Arsenal, where the necessary design studies will be made to recondition the carriage, replacing the defective ma-

terial and incorporating such improvements as can readily be made without rebuilding the entire carriage.

The track will be modified, a track link with a swinging or swivel shoe will be substituted for the present type of link. The more flexible type of track will relieve the strains on the track because of its ability to follow the contour of the ground.

The present type of divided roller frame will be retained, but a change will be made in mounting the truck wheels, which will be mounted in pairs on pivoted bogie frames attached to the roller frames.

The combination of a more flexible type of track with the pivoted bogie will result in relieving the strains on the running gear and reduce the breakage of track links and rollers due to the concentration of loads caused by the present type of construction.

Medium Tank, Model 1922.—The Medium Tank, Model 1922, has been under test at the Aberdeen Proving Ground since its preliminary shop testing at Rock Island Arsenal.

This tank is equipped with a running gear different from the conventional type. The truck rollers, instead of being mounted on gudgeons fixed in the side plates, are mounted in pairs to make up a series of small trucks. The trucks have vertical motion only, the vertical motion being limited by two steel cables which pass over small sheaves mounted in each truck frame above the track rollers. The cable is prevented from moving vertically with the truck by sheaves mounted on axles fixed in the side plates of the tank. One end of the cable is fixed while the other end is free to move horizontally against the tension of a spring.

The weight of the tank is carried by the cables, two on each side of the tank, the load being transmitted to the cable through the sheaves fixed to the tank frame, the cable in turn transmitting the load to the trucks and through the trucks to the tracks.

The purpose of this type of suspension is to permit the track following the contour of the ground, thus distributing the weight and avoiding concentration of weight at one or more points on the track. The track wear is reduced and the vehicle on a whole rides much easier.

The tank is the first vehicle of the heavy type to be equipped with this type of suspension and the installation was experimental. It was thought the cable would have a short life, but it was decided to operate the tank to determine the maximum life to be expected from this type of suspension. After a total of 200 miles, the cable on one side failed.

The mileage indicates that this suspension has too short a life for satisfactory service, and steps are being taken to replace the cable with a flat roller chain. The chain suspension is being used with success in a commercial vehicle, having a similar type of construction.

The performance of the chain suspension will be watched with interest since this same type of suspension is proposed for other vehicles now under design.

Frankford Arsenal

Investigation of Thermal Variations in Range Finder End Reflectors.—Problems in range finder design occupy a very important place in the development of improved optical instruments for fire control. But contrary to a seemingly prevalent notion, the present shortcomings in these instruments are due to imperfections in the mechanical design rather than to unavoidable difficulties in the optical design. The specialized training which one must possess in a high degree to really succeed in producing optical designs of the best quality has made it comparatively easy for masters of the art to provide optical systems of satisfactory performance for rangefinder work. But on the other hand, engineers and designers even of mature experience along other lines of instrument design are seldom qualified to cope with problems of optical instrument design in general, and in rangefinder work fail to appreciate the influence of factors of extreme importance. Some of the largest and best optical firms have, in the past, produced designs showing a surprising disregard for certain rather obvious and all-important factors. Fortunately more recent designs show considerable improvement.

One of the important problems in rangefinder development is the design of the end reflectors. Much work on this problem has been done by firms engaged in rangefinder manufacture, but naturally the results of these investigations are not generally available. Moreover, a survey of the types of end reflectors used in the more recent models leads to the belief that further improvement is possible.

A most desirable quality for an end reflector to possess is constancy of deviation during temperature changes of an irregular kind or for non-uniformity of temperature. Theoretical considerations, taking into account all the physical—including thermal—properties of materials, point out the leads to best results.

In order to investigate experimentally the relative merits of various end reflectors, it is necessary to arrange laboratory devices of extreme sensitivity. Moreover, since the end reflectors change continuously under the application of heat—and very quickly in some cases—it is highly desirable to arrange the apparatus to furnish a continuous indication. A sturdy supporting post is provided on which the end reflector to be studied may be placed. This post also carries a reference prism so designed that it will betray any angular movement of the post itself. The reference prism and the supporting post are shielded from the heat applied to the end reflector. Moreover, precautions are taken that the applied heat shall produce no relative motion of the end reflector and the reference prism. Light from a distant artificial star is reflected from these parts into a telescope objective of large diameter and long focus. Both star images formed by this objective are brought into the field of view of a microscope where any relative motion of the two may be readily and continuously observed. When heat is applied, one may watch the changes in deviation and sometimes in definition, as they progress, and on shutting off the heat, a record of the cooling may be obtained. With this method of experimentation, it is a comparatively easy matter to determine the relative merits of various end reflectors. Moreover, it is possible to determine when the variations in deviation due to thermal conditions

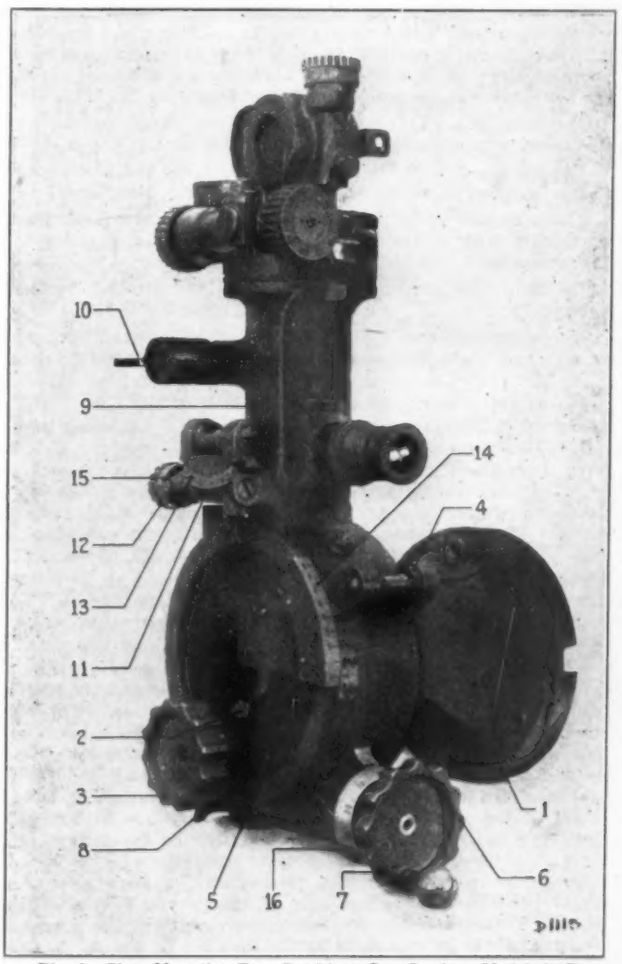


Fig. 3. Sight Mounting Type S, 4.7 inch Gun Carriage, Model 1922E

prevailing in the use of rangefinders have been reduced to a negligible amount.

Unfortunately, no end reflector has yet been found that satisfies this condition, although an experimental end reflector built to conform to some of the conclusions of the theory of thermal variations in end reflectors comprises an advance in the desired direction.

Sight Mounting, Type S.—Figure 3 shows the Sight Mounting, Type S, for use on the new experimental 4.7-inch Gun Carriage, Model of 1922E.

The sight mounting is attached to the cradle trunnion by means of the bracket (1), which contains the cross-leveling worm segment (2) and the bearing for the pin forming the fulcrum about which the mounting rotates for leveling. The knob (3) controls this movement and the cross level (4) is provided for indicating when level.

The cross-leveling worm is enclosed within the housing (5) which is provided with bearings for the fulcrum pin. Its outer diameter forms a bearing for the body (6) and contains a worm segment which engages the elevation worm housed within the body, the movement of which is controlled by the knob (7).

The wing nut (8) operates a clamping device to prevent the rotation of the elevating worm during firing.

The sight socket (9) is attached to the body and is designed to receive the Panoramic Sight, Model of 1917 (Modified).

The wing nut (10) when rotated disengages the sight from the socket and in the position shown retains it rigidly, by the action of a torsional spring.

The angle of site mechanism (11) is controlled by the knob (12).

The scales (13 and 14) are graduated to indicate hundreds of mils and the micrometers (15 and 16) indicate single mils.

Emergency Sighting System for 3-inch A. A. Gun Mount, Model of 1923E.—Designs are being completed and work inaugurated on an emergency system of sighting for the 3-inch A. A. Gun Mount, Model of 1923. While the primary method of laying this gun is to be Case III, nevertheless it has been deemed advisable to apply a sighting mechanism to the mount so that if it ever occurs that the central station computer fails in its resolution of Case III data, there will be available pointing devices attached to the guns, whereby Case II firing can be realized. With this emergency sighting system four operators are, under normal conditions, considered necessary, although three might suffice.

The telescope with which the laying of the gun in azimuth is governed will be of the wide angle eyepiece type having a large field and magnification of approximately six. The observer continuously follows the target by manipulating small handwheels that are attached to easily operated mechanisms of this telescope mounting. He will be disturbed in his observations by the operator who rotates the traversing handwheel of the gun mount, there being no attempt to interlink these two movements by a differential in the traversing gear train. In view of the wide field of the telescope and from appreciation of the fact that this sighting system is of secondary or emergent importance, it was not considered necessary to interconnect the traversing movements of the telescope and the mount as was done in the instance of the A. A. Gun Mounts, Model of 1920.

The azimuth layer of the gun rotates the traversing handwheel of the carriage until a reference line or pointer that the observer controls is brought to coincidence with a graduation of a ring scale, the value of which is announced. His operations are therefore analogous to those required in the "follow-the-pointer" system quite generally employed in naval gunnery.

Quadrant elevation can be determined in function of the fuse setting and altitude or fuse setting and angle of site. The carriage is accordingly equipped with a cylinder around which is enveloped an abaci of constant fuse settings. This is driven from the trunnions of the gun under control of the operator who turns the gun-elevating handwheels. A scale bearing graduations of altitudes and angles of site, upon which a slider rides completes the requisite elements for resolving quadrant elevation. To one edge of this drum is attached the mil scale with its micrometer which is referred to for elevational settings in Case II firing.

A gun type range computer and a fuse setter, mounted opposite the breech and in line with the loading tray of the gun, have been provided as accessory equipment.

Watertown Arsenal

Failure of Recoil Valves.—While the 16-inch Barbette Carriage, Model of 1919, was being proof fired at the Aberdeen Proving Ground, failure of one of the recoil valves occurred. A metallurgical examination has been conducted on this valve with the following results:

Tensile Tests

(D886-1 Broken Valve.)

Marks	Yield point lbs. per sq. in.	Tensile strength lbs. per sq. in.	Elongation in 2-in.	Contraction of area per cent
D886-1-1	65,330	102,660	6.0	18.5
D886-1-2	64,000	110,660	8.5	12.5
D886-12-1	61,330	86,660	4.0	6.4
D886-12-2	64,000	101,330	5.0	6.4

Charpey Test

Marks	Ft. lbs.
D886-1-1	8.98
D886-1-1	4.75
D886-1-2	5.37
D886-1-2	4.04
D886-12-1	6.75
D886-12-1	4.55
D886-12-2	5.90
D886-12-2	4.65

Tensile Tests on Bronze Pistons

(Piston 1994 from Cylinder Having Broken Valve.)

Marks	Yield point lbs. per sq. in.	Tensile strength lbs. per sq. in.	Elongation in 2-in.	Contraction of area per cent
1990-1	71,000	105,750	11.0	16.9
1990-2	67,000	107,250	13.0	20.5
1994-1	68,000	101,500	7.0	13.3
1994-2	68,000	102,250	7.5	16.9

The yield point on all the tensile specimens taken from the valve was well above that required for Forged Steel "A." The elongation and contraction on both valves was very low and not at all comparable with the acceptance test. This is accounted for by the fact that the acceptance test was taken from the bar midway between the center and exterior, whereas the tensile test from the broken valve came from a point much closer to the center of the bar. The valve which failed had a better ductility than the valve which did not fail.

Charpy tests were also taken from the stem of the valve and were dangerously low in both valves.

Brinell tests taken upon sections cut from the valves showed a very uniform hardness throughout.

It is believed that Forging D886, from which both valves were machined, had a spongy center, which accounts for the poor ductility and Charpy figures found in the tests taken from the stems of the valves. The deformation observed on the seat of the valves, which is a direct measure of the forces applied in service, indicates beyond dispute that the stresses to which these valves were subjected exceeded their elastic limit. As both valves showed this deformation, the elastic limit was exceeded prior to any breakage of the valves.

It is believed that Forged Steel "A" is not satisfactory for these valves, and regardless of the type of steel adopted for replacement it is believed very necessary to take impact tests in addition to the regular tests required.

Reserve Corps Notes

A few Ordnance Reserve Officers of the B. A. Group have been trained at Ordnance establishments during the past month by the Corps Area Commanders. Two officers were ordered to Rock Island Arsenal, two to Raritan Arsenal, and one to Frankford Arsenal.

Training for the balance of the fiscal year 1923 has been suspended by the Corps Area Commanders due to a decision of the Comptroller allowing claims for commutation of quarters for officers already trained. These valid claims for allowance of quarters are being paid out of the available funds remaining for fiscal year 1923.

Training plans for the fiscal year 1924 are being pushed forward by the Corps Area Commanders and all applications for summer training at regular Army stations should be made to the Commander of the Corps Area in which the officer resides.

The following Reserve Officers have accepted commissions since the last issue:

Col. Bascom Little	2nd Lt. Charles S. Smith
Col. James L. Walsh	2nd Lt. Alexander Singer
Lt. Col. Thomas E. Durban	2nd Lt. Robert I. Boland
Major Raymond A. Brown	2nd Lt. Christian H. Early
Major Charles W. Savage	2nd Lt. Henry S. Moulthrop
Major Herman F. Stone	2nd Lt. Herman C. Terrien
Capt. Warren H. Atheron	2nd Lt. Edward M. Byrne
Capt. Frederick R. Clark	2nd Lt. Joseph P. Moran
Capt. George W. Coslick	2nd Lt. Clarence C. Stevens
Capt. Archibald D. Methven	2nd Lt. William E. Gumm
Capt. Matthew D. Phillips	2nd Lt. August P. Diehl
Capt. Albert A. Hedge	2nd Lt. Frederick W. Bresler
Capt. Claudius H. Roberts	2nd Lt. Walter C. Lawson
Capt. Lindley G. Schmidt	2nd Lt. Edgar C. Pierson
Capt. Herbert E. West	2nd Lt. Henry C. McDonald
1st Lt. William B. Howard	2nd Lt. Horace E. Craig
1st Lt. Isaac B. Shaw	2nd Lt. Earle Gosser
1st Lt. Alfred W. Berrard	2nd Lt. Charles W. Simmons
1st Lt. Charles E. Neville	2nd Lt. Walter I. Ettleman

The Office of the Chief of Ordnance started the first issue, in pamphlet form, of a bi-monthly news letter to all Reserve Officers of the Ordnance Department. The first issue was General Pe.rce's lecture delivered at the War College on "Industrial War Plans of the Ordnance Department." The purpose of these bi-monthly letters is to keep the Reserve Officer in touch with the activities of the Ordnance Department in time of peace.

LT. COL. CLARE F. BEAMES

Lt. Col. Clare F. Beames, Ordnance O. R. C., died on April 22, 1923, at his home, 125 Twentieth Street, Jackson Heights, Elmhurst, L. I. Colonel Beames was a highly educated and able electrical and power engineer, and had for many years held responsible positions with public service corporations. He had represented companies like Bonbright & Co., Electric Bond and Share Co., and others; made industrial surveys throughout South America and in Mexico, and was for several years chief electrician for the Maharajah of Mysore, for whom he supervised a number of important power and electric installations.

Colonel Beames was by request assigned early in 1918 to the Nitrate Division, Ordnance Department, where his wide experience and thorough knowledge of large power installation and operation and electric transmission were most helpful in the negotiation of contracts and supervision of work of that nature. His services were so valuable in these directions that he received a promotion from the grade of Major to Lieutenant Colonel, and after the close of the war was induced to remain in active service for over a year to close up important transactions.

Colonel Beames was a man of high principles and of ardent patriotism; as a reserve officer he took a keen interest in the work of the military and Ordnance authorities toward preparedness, both military and industrial. He was active in the Army Ordnance Association and in the New York Post—always ready to lend his willing assistance.

Recently Colonel Beames and other heirs donated to the U. S. Military Academy at West Point, N. Y., one of the most complete and valuable collections of organ music in existence, The "Mazenet Library," which valued gift was most gratefully accepted and placed in the Cadet Chapel.

Make This Coupon Productive: Bring In a New Member

ELIGIBILITY

American citizens who have held positions of responsibility in connection with the design, procurement, production, manufacture, inspection, test or supply of Ordnance during the World War, or who occupy positions in civil life which would render them available for assisting in the production of Ordnance in the event of war, are eligible for membership.

Date.....

THE SECRETARY

ARMY ORDNANCE ASSOCIATION

Munsey Building, Washington, D. C.

I desire to enroll as a Member of the ARMY ORDNANCE ASSOCIATION, and enclose check for $5.00 to cover annual dues for one year from date, of which $3.00 is for a year's subscription to ARMY ORDNANCE—the official Journal of the Association.

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Recent Patents

Brief Descriptions of Inventions of Interest to Ordnance Engineers

Compiled by W. N. Roach, Chief, Patent Section, Office of the Chief of Ordnance.

WHILE the activities of inventors have been directed, of late, mostly to the commercial arts, there are still a number of patents being issued in the field of ordnance which are of more or less interest to those making a special study of these subjects, or who are engaged in the development of ordnance.

Small Arms and Accessories

The following patents will prove of special interest to those engaged in the development of Fire Arms and Accessories.

Patent No. 1,452,465, issued to Millard L. Johnson, for an actuator for machine guns, shows a gun of the gas operated type, in which a dog is provided to hold a hammer and prevent it from striking the firing pin until the breech bolt has pushed the cartridge home in the cartridge chamber.

Patent No. 1,452,123, issued to John C. R. McCrudden, for a machine gun, discloses a machine gun of the automatic recoil type, of comparatively light weight, which may be rapidly and easily recharged, and having means for regulating the rate of fire and varying the rate while the gun is in operation, and which has special means for cooling the barrel. The gun is convertible to a single fire shoulder arm.

Patent No. 1,452,042, issued to Grant Hammond, assignor of 1/3 to Alva C. Washburne and 1/3 to Frederick G. Crane, for a magazine catch and release for fire arms, discloses a fire arm provided with a magazine chamber in which a magazine may be removably located, the magazine having the usual spring and follower, and a releasing member mounted in the frame of the fire arm adjacent the magazine chamber, having means thereon to engage the follower to operate the releasing member and means for moving the releasing member in a direction opposite to that in which it is moved by the follower, and a catch for holding the magazine in place. The releasing member has cams extending in opposite directions to engage the catch and a space between the cams to receive the catch and permit it to engage the magazine and hold it in place.

Patent No. 1,452,000, issued to Nicolas Pieper, for a disjointing device for automatic pistols, shows an automatic pistol with the usual form of slide covering the barrel, the bolt forming a part of the slide, and its recoil being delayed by a recovering spring, and means for holding the recovering spring in compressed position to enable the fire arm to be taken apart. The means shown consists in an elastic plate secured on the grip and provided with a claw, the claw being in a position to engage the spring whenever pressure is exerted upon the elastic plate.

Patent No. 1,451,584, issued to James R. Mapes, for a gun sight, discloses a gun sight, adapted for rigid connection to the stock in advance of the hammer and in such position as to avoid the risk of contacting with the face of the user due to recoil of the gun or when bringing the piece to the shoulder. The sight is provided with adjustments for aligning the sights, to allow for windage, and to vary the elevation, and has a special form of peep sight mounted thereon.

Patent No. 1,451,294, issued to Louis C. A. DeB. Doucet, for fire arm for teaching or practicing or aiming thereof, and for adapting the same for signaling, discloses a fire arm the barrel of which is a tube fitted with lenses, in the breech end of which tube is mounted a reflector and a flash light lamp, the object being to flash the rays of the spot light upon the target when the trigger is pulled; the pulling of the trigger making contact in the electrical circuit of the lamp.

Patent No. 1,451,339, issued to Arthur Kottas, for a magazine fire arm, discloses an arm having a tunneled stock into which cartridges may be fed, either singly or in sets, downwardly through an orifice in the stock, and in which tunnel each cartridge is laid transversely of the stock and through which the cartridges are drawn by a special belt running through the tunnel.

Patent No. 1,450,976, issued to Edward Larsen, for a safety device for portable fire arms, discloses a fire arm having a safety adjustment consisting of two members, for locking the trigger independently of each other, the locking members each having a part projecting outside the handle of the stock so that the locking members are released on seizing the stock in firing, and means for causing these locking members to be locked automatically in the released position after discharge. From this construction, in a hammerless gun, the operator can tell from the position of the locking members whether the gun is loaded or not and if loaded, whether one or both of the cartridges have been fired.

Patent No. 1,451,137, issued to F. L. Bailey, for a ventilated hand protector for guns, shows a device formed to slide over a gun barrel or barrels, having spaced inner and outer portions through which air may circulate, the form of the outer portion being such as to provide an easy grip.

Patent No. 1,451,443, issued to Elbert Fowler, and licensed to the United States Government, for a machine gun, discloses a machine gun of the recoil-operated type in which the number of parts have been reduced by providing certain parts which perform dual functions, such as the extractor which extracts the cartridge from the feed belt and also cocks the firing pin. The cartridge extractor is pivoted on an instant pivot so that the front end moves downward in substantially a straight line. The extractor is also mounted on the breech bolt in such a manner that it may be removed from the bolt without withdrawing the bolt from the gun. The gun also has novel features consisting of ejector construction; a mechanism for locking the breech bolt, trigger and sear mechanism; belt feeding mechanism, and a novel safety locking means,

Patent No. 1,450,834, issued to Theodore Bergman, for a machine pistol, discloses a pistol having a sleeve connected to the breech frame provided with a channel through which

the cartridges are fed to the barrel, and an opening to which the spent cartridges are ejected.

Patent No. 1,450,823, issued to Isaac C. Spencer, for a rifle sight, discloses a front sight provided with a plurality of colored beads, which indicate the sight to be used for a predetermined range and a rear sight mounted for step-by-step vertical adjustment and having an adjustable peep sight thereon.

Patent No. 1,450,653, issued to Carl Swebilius, assignor to Marlin Fire Arms Corporation, for an automatic gun, discloses a fire control mechanism operating on higher frequency than the firing frequency of the gun to effect the firing of the gun at a definite time. This object is attained by providing a trigger adapted for continuous operation by impulses transmitted thereto, and provided with means to render it inoperative to effect the firing of the gun except on the operation of the trigger next succeeding the complete breeching of the gun.

Patent No. 1,450,596, issued to Ellison D. Henry, for a fire arm, discloses a gun of the automatic type provided with a tubular magazine in which the cartridges or shells are received and having a removable extension to increase the capacity of the magazine.

Patent No. 1,450,379, issued to James E. McNary, assignor to John W. Weeks, Secretary of War, for a helmet, discloses a helmet of special form similar to that known as the "Liberty Helmet."

Patent No. 1,450,349, issued to Warren S. Belding, for a telescope rifle sight, discloses a mount for a telescopic rifle sight in which two bases are provided, rigidly connected and permanently spaced apart by a metallic member, each base provided with a stop, and a mount for each base provided with adjusting devices for the telescopic tube.

Patent No. 1,450,037, issued to Jos. A. Heiman, for a gun cleaning and oiling rod, discloses a telescoping rod, having means on each section for locking the sections in extended position.

Patent No. 1,449,775, issued to Otto Niedner, assignor to Niedner Rifle Barrel Company, for a shell loading tool, discloses a shell loading tool which may be rapidly manipulated; which may be adapted to shells of different sizes and shape and which enables the bullet to be set in a very accurate manner.

Patent No. 1,449,650, issued to Frank F. Burton and Arthur Rowley, assignors to Winchester Repeating Arms Co., for a bolt action fire arm. The invention discloses a bolt action, take-down fire arm possessing certain refinements which make for simplicity, safety in use, accuracy, and ease of operation, in which a stock unit is provided to be handled as one piece, and comprises a stock, a trigger and sear; a receiver unit to be handled as one piece, consisting of a receiver, a barrel and a breech bolt; the units being provided with pairs of interlocking members of which one pair is positioned to cooperate with the breech bolt to hold both pairs of locking members in locking engagement when the bolt has engaged the lock.

Patent No. 1,449,566, issued to Fritz Walther, for an automatic pistol, discloses an automatic pistol, in which a locking piece for locking the breech block on the pistol handle is connected to the trigger guard.

Patent No. 1,448,297, issued to Eugene F. Hendrick, for a fire arm, discloses a semiautomatic breech-loading fire-arm in which the breech block is moved vertically by means of a lever and which contains a main spring for the hammer which also retains the lever and breech block in closed position and causes the lever to complete its down stroke rapidly and operate to eject the shell.

Patent No. 1,448,861, issued to James S. Johnston, for a cocking mechanism for automatic machine guns, discloses an automatic gun provided with novel means located adjacent to the trigger for cocking the gun so that the hand of the operator will not be shifted from one part of the gun to another during this operation.

Patent No. 1,447,860, issued to James S. Johnston, for a cartridge magazine for machine guns, discloses a special form of cartridge magazine so constructed that the expended shells are used for forcing the loaded shells into loading position. This is accomplished by so constructing the magazine that the expended shells are delivered to the magazine and operate to force the loaded shells through it.

Patent No. 1,447,246, issued to George Hazelton, assignor to Vickers Ltd., for a machine gun. The invention discloses certain refinements in a gun of the Vickers type devised for the purpose of speeding up action of the gun.

Patent No. 1,446,763, issued to Chas. A. Nelson, assignor to Savage Arms Corporation, for a fire arm, discloses a fire arm having a novel structure and relationship of parts which control the breech bolt and the hammer or striker, the object being to reduce the number of parts and simplify construction.

Patent No. 1,446,635, issued to Andre V. P. M. Berthier, assignor to United States Machine Gun Company, for a fire arm, shows a machine gun intended primarily for use on aircraft, consisting of a multi-barrel machine gun, having a plurality of independent operating and firing mechanisms, a controlling handle for the gun, and unitary mechanical means apart from the handle for rendering the operating mechanisms jointly operative, so positioned that it can be operated by the hand grasping the controlling handle.

Patent No. 1,446,388, issued to Ernst Ludorf, for a machine gun, discloses a machine gun constructed of a comparatively small number of parts, and having means to damp the recoil in such a manner that the initial speed of the projectile leaving the muzzle of the gun is the same in vertical or horizontal position of the gun. The gun is provided with a fluid brake of improved construction, and also with novel means for feeding the cartridge into the gun.

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Patent No. 1,447,478, issued to Emil J. and Alois J. Koshollek, for a bullet. This bullet is intended primarily for use in hunting big game, comprising a solid metal body axially bored at the nose and for a suitable distance; the bore billed with a lead slug, and the nose swaged or ward end of which will mushroom when brought in contact crimped in, giving a bullet of high penetration, the forwith animal tissue.

Ammunition

Patent No. 1,447,023, issued to Christian Kaiser, for a projectile, adds another to the series of projectiles which have been devised for the purpose of securing greater range by forming the projectile with booster sections containing explosive which is successively exploded during flight and thus imparts successive impulses to the projectile. The novelty in this particular device consists of the firing means employed for successively igniting the booster charges.

Patent No. 1,446,764, issued to Henry J. Nichols for a water impact fuse, shows a fuse in which are contained two telescoped plungers, the inner one carrying a firing pin and the outer carrying a primer. The nose of the fuse is provided with an aperture through which water may enter. Retardation of the shell by impact with the water will, through inertia, cause both plungers to move forward. Water rushing through the aperture will impinge upon the head of the inner plunger causing it to move to the rear. The water after striking upon the inner plunger will, because of the formation of the plunger head, be deflected to the inner face of the head of the outer plunger causing it to move forward, thus bringing the firing pin and primer together with sufficient force to prime the latter.

Book Review

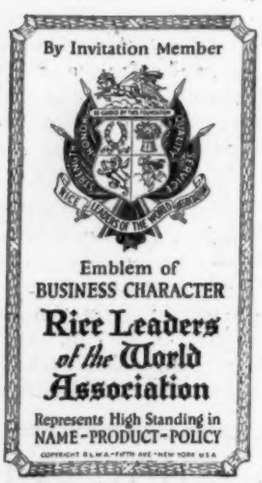
"Industrial America in the World War." By Grosvenor B. Clarkson, Houghton Mifflin Company. Price, $6.00.

Mr. Clarkson has written a most vivid account of American industrial accomplishment of the World War. The story is all the more captivating coming as it does from one who served as chairman of the Advisory Commission of the Council of National Defense and also as chairman of the Inter-Departmental Defense Board. Mr. Clarkson occupied a position which gave him exceptional opportunities to observe the gradual unfolding and crystalization of America's industrial effort. He speaks from first hand knowledge and with evident attempt to deal fairly with all concerned.

The preparation of the book shows care and finish; the author describes the evolution and workings of the War Industries Board, the caliber of those who guided its destinies, and the conditions under which such marvelous results were obtained. The value of "Industrial America in the World War" will enhance as time goes on. While it covers much of the same ground already chronicled from a different viewpoint by Messrs. Crowell and Wilson in their monumental work of two years ago, "How America Went to War," still America's industrial achievement in the greatest of all wars can well stand more commentaries for posterity's sake if for no other. Every student of industrial preparedness, of political economy and of national government would do well to read Mr. Clarkson's book. We commend it particularly to those who desire a permanent record of the united effort of American capital, American labor and American ingenuity during the World War.

L. A. C.

DEPENDABLE AMMUNITION!



Dependability is one of the prime requisites of good ammunition. If velocities and pressures vary to any great degree, the shooter cannot plan his shots for the reason that he knows not what to expect of his ammunition. Such ammunition is not dependable because its ballistics are not uniform.

From the very beginning, Peters ammunition has been looked upon by users, as ammunition to be depended upon. This reputation is the result of a policy followed by The Peters Cartridge Company ever since its organization—that of, first, embodying in its product materials of only the highest quality; second, the assembling of these materials into a product that would satisfy the requirements of the most discriminating user; and third, insisting upon its product measuring up to such ballistic standards as to assure results of a superior character.

It is in such a high type of manufacturing spirit that Peters ammunition is produced—all for the purpose of putting into the hands of the users of ammunition loads of superior quality.

The (P) brand of ammunition consists of a full and complete line of Rim Fire, Pistol and Revolver, Military and Sporting Cartridges, and Shotgun Shells.

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